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Recommended Species for Vegetative Stabilization of Training Lands in Arid and Semi-Arid Environments

United States Department of Defense, Army Corps of Engineers

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USA-CERL

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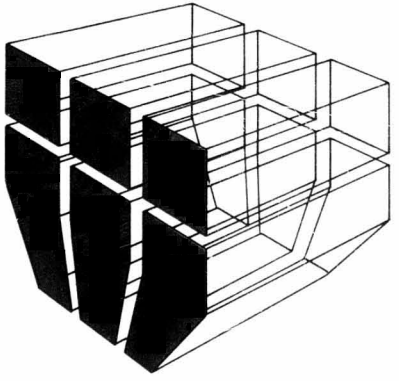
Recommended Species for Vegetative Stabilization of Training Lands in Arid and Semi-Arid Environments



Maintaining natural resources on western military installations has received increasing attention in recent years. Of special interest are training ranges where the environmental impact of tracked and wheeled vehicles is significant. Revegetation and soil stabilization on the arid and semi-arid regions of these western installations require special techniques. This report identifies key plant species that may be useful to installation land managers seeking to maintain or rehabilitate training lands in these areas. The plant species are described in terms of their regional and environmental adaptations, limitations, uses, establishment requirements, and availability. In addition, recommendations for short- and long-term revegetation efforts have been made for selected western installations.

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Maintaining natural resources on western military installations has received increasing attention in recent years. Of special interest are training ranges where the environmental impact of tracked and wheeled vehicles is significant. Revegetation and soil stabilization on the arid and semi-arid regions of these western installations require special techniques. This report identifies key plant species that may be useful to installation land managers seeking to maintain or rehabilitate training lands in these areas. The plant species are described in terms of their regional and environmental

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adaptations, limitations, uses, establishment requirements, and availability. In addition, recommendations for short- and long-term revegetation efforts have been made for selected western installations.

FOREWORD

This investigation was performed for the Office of the Assistant Chief of Engineers (OACE) under Project 4A162720A896, "Environmental Quality Technology"; Task A, "Installation Environmental Management Strategy"; Work Unit 030, "Guild Based Training Area Maintenance." The work was performed by the U.S. Army Engineer Waterways Experiment Station (WES) for the Environmental Division (EN) of the U.S. Army Construction Engineering Research Laboratory (USA-CERL), under Intra-Army Order 83-D05, dated 19 October 1983.

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Dr. R. K. Jain is Chief of USA-CERL-EN. COL Paul J. Theuer is Commander and Director of USA-CERL, and Dr. L. R. Shaffer is Technical Director.

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OF TRAINING LANDS IN ARID AND SEMI-ARID ENVIRONMENTS

1 INTRODUCTION

Background

The Department of the Army manages more than 4 million ha of training and maneuver ranges, including arid and semi-arid areas in the western United States. Military training activities frequently impact the natural resources of these areas. This results in soil compaction and erosion, vegetation destruction, plant community and wildlife habitat changes, dust problems, and diminished training realism through loss of natural topography and vegetation. Army natural resource managers at western installations are dealing with the problem through a variety of management plans. Such plans often incorporate vegetative stabilization measures such as new seedings, control of severely eroded areas, rotational training agreements, limited public recreational and grazing use, and other site-specific considerations.

The Army's broad objective is to maintain an areas's environmental resources while providing adequate training facilities for personnel using tracked vehicles such as tanks, armored personnel carriers, and infantry fighting vehicles. The facilities include both existing training ranges and the planned Multi-Purpose Range Complexes (MPRC) on which troops will be able to engage mobile targets while moving downrange. Training lands are subject to intensive use, with outlying areas on the larger ranges receiving occasional or rotational use. Thus, from the land manager's standpoint, protecting and managing these areas' natural resources and providing training realism are continuing challenges.

To help solve these problems, installation land managers need information to identify and prioritize plant species having potential use for stabilization on training areas. Such information will be useful in making decisions regarding ongoing and future management policies.

Objective

The objectives of this research were (1) to prepare a list of recommended plant species suitable for stabilizing training range lands in arid and semi-arid regions and to provide requirements and management information for each recommended species, and (2) to recommend short- and long-term revegetation methods for use at selected Army installations.

Approach

Existing databases on arid and semi-arid plant species suitable for rehabilitation were examined. Information was also obtained from civilian and military experts. Based on the data provided by these sources, a list of plant species and their growth requirements was prepared and compared to the

environmental conditions at major Army installations conducting cross-country vehicle maneuvers.

Mode of Technology Transfer

It is recommended that the material in this report be used in the U.S. Army Construction Engineering Research Laboratory (USA-CERL) facility technology application test program on training area maintenance. It is also recommended that the proposals be published in an Engineering Technical Note.

2 REVEGETATION RECOMMENDATIONS FOR SELECTED MILITARY INSTALLATIONS

Based on information obtained from the literature, the findings of previous research, and records in installation environmental offices, several revegetation recommendations have been made for the six selected military installations.

There are two general classifications of disturbance on military lands: (1) severely or moderately disturbed areas that are impacted once, then not disturbed again for a long time (long-term) and (2) severely disturbed areas that are continually impacted by military activities and that will have no relief from disturbance (short-term). Examples of these two types of disturbance occur on all military installations in the United States that have tracked and wheeled vehicle training areas.

This chapter provides stabilization recommendations for both types of disturbances along with examples of their application at selected military installations. Actual applications of these recommendations at other installations should consider site-specific needs. Areas disturbed by realistic training exercises that are to be evaluated for revegetation should be divided into two categories: (1) areas that will be disturbed in less than 2 years (short-term stabilization sites) and (2) areas that will not be disturbed for more than 2 but less than 10 years (long-term stabilization sites). Vegetative stabilization of long-term sites requires different seed mixtures, seedbed preparation, and seeding equipment to control erosion than short-term sites.

Long-Term Stabilization

Seed mixtures and seeding techniques for long-term stabilization use traditional range and surface mine disturbed-site seeding methods to establish perennial grasses and forbs. Species are used that have been found to provide the most cost- and manpower-efficient stabilizers as well as erosion control. Successful establishment of long-lived perennial vegetation costs less than repeated seedings for short-term stabilization projects or installing physical structures on small, continually disturbed, erodable sites.

The approach used to formulate long-term stabilization recommendations was based on methods and plant species that require a minimum of funding, manpower, application, time, and specialized equipment.

Surface soil samples, 0 to 25 cm deep, should be taken before any revegetation work to identify nutrient, chemical, or physical properties that would be detrimental to plant establishment. Soil samples can be analyzed at either a university soil laboratory or a private research laboratory for a minimal fee. The primary soil properties to be determined are pH, soil texture, available soil water, electrical conductivity (EC), sodium absorption ratio (SAR), nitrogen (total N, NH^{+4}, NO^{-3}), phosphorus, potassium, calcium, magnesium, sodium, and cation exchange capacity. The pH, EC, and SAR values will indicate if special soil amendments other than nitrogen, phosphorus, or potassium are required to modify soil conditions that may be toxic to plants. On

most impacted areas at the selected installations, soils are not overly acidic, alkaline, saline, or sodic. However, if there are indications of toxicity, soil amendments and specialized seed mixtures will be required. Soil texture will indicate seed mixtures that will be best adapted to each site. Nitrogen, phosphorus, and potassium levels will give specific information on basic soil nutrient status. General fertilizer recommendations can then be modified to meet specific nutrient limitations and plant needs.

Appropriate mechanical techniques should be used to control existing undesirable vegetation. The next step is to make any necessary modifications of the soil surface to reduce runoff, erosion, and soil compaction, to incorporate any necessary immobile fertilizer nutrients, and to prepare the seedbed for seeding. Military installations in more arid environments (Forts Irwin, Bliss, and Carson) will require more intensive and costly soil modification treatments than those in more humid environments (Forts Riley, Sill, and Hood). Pitting has been used successfully on gentle terrain (slopes less than 20 percent) at Fort Carson.[1] If pitting is deemed necessary for best plant growth, it should be done immediately before seeding, using available standard range-pitting equipment. Pitting is suitable only on medium- and fine-textured soils, and seeded stands will be established successfully only if competition from existing vegetation is minimal. It should be applied only on the contour to prevent excessive erosion and maximize water retention. Soil moisture levels should be adequate to minimize wind erosion hazards. Pitting on disturbed sites at Forts Irwin, Bliss, and Carson will probably improve seeded stand establishment.

Disking and harrowing have been used successfully just before seeding at Fort Hood.[2] Disking and harrowing should be done on any site when soil moisture is adequate but soils are not wet. Existing herbaceous vegetation should be disturbed sufficiently to create gaps that will allow seeded species to establish with minimum competition, but it is not necessary and probably not desirable to have a clean seedbed with no vegetation remaining. The final seedbed soil should be firm but not compacted or powdery (indications of operating in overly wet and dry soils, respectively). This seedbed preparation treatment may also be desirable on gentle terrain at Forts Sill and Riley, but has not been tested there.

Fairly immobile fertilizer nutrients such as phosphorus should be broadcast after pitting at Forts Carson, Bliss, and Irwin, and before disking or harrowing at Forts Hood, Riley, and Sill. More mobile fertilizer nutrients such as nitrogen should be applied by aerial- or machine-broadcasting after seedlings begin to emerge during the first growing season after seeding. This will allow the nitrogen to dissolve with seasonal rainfall and provide immediate nitrogen availability to seedlings while reducing volatilization and leaching losses. Nitrogen application before seedling emergence is undesirable since weed species that germinate and begin growing sooner than seeded species will use the available nitrogen. Table 1 lists recommended fertilization rates for each military installation.

[1]Roy Cammack, 1983, Soil Conservation Service, personal communication.
[2]Norman Dunbar, 1983, Fort Hood, personal communication.

Table 1

General Fertilization Rates Recommended for Selected Western Military Installations

Location	Nitrogen (kg N/ha)	kg/Ammonium Nitrate/ha	Phosphorus (kg P/ha)	kg Triple Superphosphate/ha
Fort Riley (eastern Kansas)	45-55	60-75	65-90	80-110
Fort Sill (western Oklahoma)	50-60	65-80	30-60	35-70
Fort Carson (central Colorado)	50-60	65-80	30	35
Fort Hood (central Texas)	80	110	80	95
Fort Bliss (west Texas and southeast New Mexico)	30-50	40-65	20-30	25-35
Fort Irwin (southeast California)*	30-55	40-75	40-70	50-85

*Ammonium phosphate sulfate (16-20-0) can also be used at Fort Irwin at a rate of 200 to 350 kg/ha.

Tables 2 through 9 give basic recommended seed mixtures for long-term stabilization of disturbed sites at Forts Bliss, Carson, Hood, Irwin, Riley, and Sill. Table 10 gives potential and optimum seeding dates of cool- and warm-season mixtures for each military installation. All recommended seed mixtures should be drill-seeded 1.3 cm deep at 180 to 270 seeds/m^2. Actual seeding rates should be calculated to reflect seed quality (purity and germinability), seed weight (lighter seeds will have more seeds per kilogram than heavy seeds), and the desired species composition within the seed mixture. It is recommended that four to eight species be used in any seed mixture to maximize success. The species selected should be adapted to the soil texture of the disturbed site and should complement each other's abilities to succeed under various environmental conditions; thus, even if one species is not established successfully under a specific set of conditions, another species in the mixture may succeed. Table 11 gives an example of calculations for a cool-season seed mixture adapted to loamy soils at Fort Carson.

Sites of fairly even terrain with a 20 to 40 percent slope should not be pitted or ripped, but rather lightly disked, seeded with a rangeland drill, and not disturbed again until vegetation is established. Contouring may be considered on the steeper slopes.

Steep slopes (greater than 40 percent) cannot be treated easily with rangeland machinery because heavy equipment cannot be operated safely on the contour. Disking and pitting equipment can occasionally be winched downslope, but this is not very practical; otherwise, no machinery can be placed on these slopes. Disk-chains or clodbusters could possibly be used to prepare the seedbed, and use of herbicides could be important in controlling undesirable vegetation. Seeds and immobile fertilizer nutrients should be broadcast by hand on small areas or broadcast mechanically on long slopes. Seeding rates on slopes should be at least doubled, and only rapidly establishing species should be selected. Mobile fertilizer nutrients should be broadcast during the first growing season after seeding.

On steep slopes, mulches and tackifiers should be applied immediately after fertilizing and seeding. For example, straw or native hay mulch should be applied at 2.5 to 4.5 MT/ha and tacked with netting or asphalt spray at 37 to 56 gal/ha. The steeper the slope and the more erosive the soil, the higher the mulch rate must be. Military installations in very arid areas (Forts Bliss and Irwin) may not have sources of inexpensive native hay or straw mulch, so alternative mulch materials or chemical tackifiers may have to be tested. If mulches are too expensive, soil erosion should be controlled as much as possible by not removing existing vegetation and by using interseeding.

Short-Term Stabilization

Training areas on military installations that are disturbed one or more times within a 2-year period will require revegetation methods that give more rapid stabilization at a lower cost than long-term stabilization techniques. These types of areas are (1) disturbed once every 1 to 3 months, (2) disturbed at a time when planting cannot be done or seedlings will not emerge within several weeks, or (3) disturbed with greater than 35 percent slope or shallow

Table 2

Seed Mixtures Recommended for Long-Term Stabilization Projects at Fort Bliss, Texas*

Species	Percent Species Composition of Seed Mixtures		
	Sand	Loam	Clay
Grasses			
Sideoats grama	0-30	0-40	0-40
Black grama	0-30	0-50	-
Blue grama	0-20	0-40	0-40
Inland saltgrass	-	0-50	0-40
Weeping lovegrass	0-40	0-30	-
Boer lovegrass	0-40	0-30	0-30
Wilman lovegrass	0-40	0-30	0-30
Arizona fescue	0-10	0-20	0-10
Galleta	-	0-20	0-30
Green sprangletop	0-10	0-10	-
Spike muhly	0-20	0-20	-
Indian ricegrass	0-40	0-20	-
Alkali sacaton	0-30	0-30	0-20
Sand dropseed	0-40	0-20	-
Woody Plants			
Fourwing saltbush	0-20	0-20	0-20
Winterfat	0-20	0-20	0-20

*No forbs are recommended on training areas at Fort Bliss for long-term revegetation.

Table 3

Warm-Season Seed Mixtures Recommended for Long-Term Stabilization Projects at Fort Carson, Colorado

Species	Percent Species Composition of Seed Mixtures			Site	
	Sand	Loam	Clay	Prairie	Foothills
Grasses					
Sand bluestem	0-40	0-20		X	X
Big bluestem	--	0-30	0-30	X	X
Yellow bluestem	0-20	0-20	0-20	X	X
Sideoats grama	0-40	0-40	0-40	X	X
Blue grama	0-20	0-20	0-20	X	X
Buffalograss	--	0-20	0-20	X	
Prairie sandreed	0-20	0-20	--	X	X
Galleta	--	0-10	0-10	X	X
Spike muhly	0-10	0-10	--	X	X
Switchgrass	--	0-10	0-10	X	
Little bluestem	0-20	0-30	--	X	X
Yellow indiangrass	0-10	0-10	0-10	X	
Alkali sacaton	0-10	0-10	0-10	X	
Sand dropseed	0-10	0-10	--	X	X
Forbs					
Cicer milkvetch	0-10	0-10	--	X	X
Northern sweetvetch	0-10	0-10	0-10		X
Yellow Sweetclover	0-10	0-10	0-10	X	
Alfalfa	0-10	0-10	0-10	X	X
Woody Plants					
Fourwing saltbush	0-10	0-20	0-20	X	X
Winterfat	0-10	0-20	0-20	X	X
Rubber rabbitbrush	0-10	0-20	0-20	X	X

Table 4

Cool-Season* Seed Mixtures Recommended for Prairie Sites for Long-Term Stabilization Projects at Fort Carson, Colorado

Species	Percent Species Composition of Seed Mixtures			Site	
Grasses	Sand	Loam	Clay	Prairie	Foothills
Thickspike wheatgrass	0-20	0-20	0-20	X	X
Desert wheatgrass	--	0-30	0-30	X	X
Tall wheatgrass	--	0-20	0-20	X	X
Intermediate wheatgrass	0-30	0-30	0-30	X	X
Streambank wheatgrass	0-20	0-20	0-20		X
Western wheatgrass	--	0-40	0-40	X	X
Slender wheatgrass	--	0-10	0-10		
Pubescent wheatgrass	0-30	0-30	0-30	X	X
Smooth brome	--	0-20	0-20		
Russian wildrye	--	0-30	0-30	X	X
Hard fescue	--	0-20	--		X
Indian ricegrass	0-20	0-10	--	X	X
Green needlegrass	--	0-20	--		X
Forbs					
Cicer milkvetch	0-10	0-10	--	X	X
Northern sweetvetch	0-10	0-10	0-10		X
Yellow sweetclover	0-10	0-10	0-10	X	X
Alfalfa	--	0-10	0-10	X	X
Woody Plants					
Fourwing saltbush	0-10	0-20	0-20	X	X
Winterfat	0-10	0-20	0-20	X	X
Rubber rabbitbrush	0-10	0-20	0-20	X	X

*Mixtures can be drill-seeded from 15 September through 28 February, weather permitting.

Table 5

Seed Mixtures Generally Recommended for Long-Term Stabilization Projects at Fort Hood, Texas*

Grasses	Percent Species Composition of Seed Mixture		
	Sand	Loam	Clay
Sand bluestem	0-40	--	--
Big bluestem	--	0-30	0-30
Yellow bluestem	--	0-30	0-30
Sideoats grama	0-30	0-40	0-40
Blue grama	--	0-20	0-20
Buffalograss	--	0-30	0-30
Green sprangletop	0-10	0-10	0-10
Kleingrass	0-20	0-20	--
Switchgrass	0-10	0-20	0-20
Little bluestem	0-40	0-40	--
Yellow indiangrass	0-20	0-20	--

*No forbs or woody species are recommended for training areas at Fort Hood for long-term revegetation.

Table 6

Seed Mixtures Recommended for Long-Term Stabilization Projects at Fort Irwin, California (Based on Vegetation Distribution Information*)

Species	Minimum and Maximum Percent Species Composition in Seed Mixture
Grasses	
Red Brome	0-30
Inland saltgrass	0-20
Boer lovegrass	0-30
Lehmann lovegrass	0-30
Cochise lovegrass	0-30
Big galleta	0-30
Mediterranean grass	0-20
Dropseed	0-30
Woody Plants	
Quailbush	0-20
Allscale	0-20
Shadscale	0-20
Blackbrush	0-20
White brittlebush	0-30
Ephedra	0-30
Shrubby buckwheat	0-40
Filaree	0-20
Spiny hopsage	0-40
Creosotebush	20-60
Triangleleaf bursage	0-20
White bursage	20-60

*No forbs are recommended for training areas at Fort Irwin for long-term revegetation.

Table 7

Warm-Season Seed Mixtures Generally Recommended for Long-Term Stabilization Projects at Fort Riley, Kansas (Based on U.S. Soil Conservation Service Guidelines*)

Species	Percent Species Composition of Seed Mixture		
Grasses	Sand	Loam/Clay	Alkaline/Saline Soils
Sand bluestem	15-30	--	--
Big bluestem	--	0-30	--
Sideoats grama	0-10	0-30	0-10
Blue grama	--	0-10	--
Buffalograss	--	0-20	0-10
Sand lovegrass	0-10	--	--
Switchgrass	10-20	0-20	0-30
Little bluestem	10-25	0-30	--
Indiangrass	15-30	0-20	0-15
Alkali sacaton	--	--	10-20
Forbs			
Birdsfoot trefoil	--	0-10	0-10
Yellow sweetclover	0-10	0-10	0-10
Alfalfa	0-10	0-10	0-10
Crownvetch	0-10	0-10	--

*No woody plants are recommended for training areas at Fort Riley for long-term revegetation.

Table 8

Cool-Season Seed Mixtures Generally Recommended for Long-Term Stabilization Projects at Fort Riley, Kansas

Species	Percent Species Composition of Seed Mixture		
Grasses	**Sand**	**Loam/Clay**	**Alkaline/Saline**
Crested wheatgrass	0-20	0-30	0-20
Tall wheatgrass	--	0-20	0-30
Intermediate wheatgrass	0-30	0-20	--
Western wheatgrass	--	10-30	15-30
Smooth brome	--	0-20	0-15
Orchardgrass	0-30	0-10	--
Tall fescue	--	0-20	0-20
Canada wildrye	--	0-10	0-10
Reed canarygrass	0-10	0-10	--
Forbs			
Yellow sweetclover	0-10	0-10	0-10
Alfalfa	0-10	0-10	0-10
Crownvetch	0-10	0-10	--

*No woody plants are recommended for training areas at Fort Riley for long-term revegetation.

Table 9

General Warm and Cool-Season Seed Mixtures Recommended for Long-Term Stabilization Projects at Fort Sill, Oklahoma*

Grass Species	Percent Composition of Seed Mixture		
Warm-Season	**Clay**	**Loam**	**Sand**
Big bluestem	10-40	10-50	--
Sand bluestem	--	--	0-35
Little bluestem	--	15-40	0-20
Yellow bluestem	0-25	0-25	--
Caucasian bluestem	0-10	0-10	--
Blue grama	10-50	0-25	--
Sideoats grama	10-50	15-35	20-30
Buffalograss	0-20	20-40	--
Switchgrass	0-20	0-50	10
Sand dropseed	--	0-10	0-10
Indiangrass	--	0-30	15-30
Sand lovegrass	--	0-20	15
Cool-Season			
Crested wheatgrass	0-30	0-30	0-30
Tall wheatgrass	0-10	0-10	--
Western wheatgrass	0-30	0-35	--
Canadian wildrye	0-20	0-20	--
Alkali sacaton	0-10	0-10	10-20

*No forbs or woody plants are recommended for training areas at Fort Sill for long-term revegetation.

Table 10

Recommended Seeding Dates for Cool- and Warm-Season Perennial Seed Mixtures at Selected Western Military Installations

Military Installation	Planting Dates	
	Cool-Season Mixtures	Warm-Season Mixtures
Fort Riley, Kansas	1 November to 30 March	15 March to 30 June
Fort Carson, Colorado	15 September to 15 May	15 October to 15 July
Fort Sill, Oklahoma	1 September to 31 March	1 December to 15 May
Fort Hood, Texas	--	15 February to 30 April
Fort Bliss, Texas	--	15 June to 30 August
Fort Irwin, California	--	1 November to 1 March

Table 11

Calculations and Explanation of a Cool-Season Seed Mixture Formulation for Loamy Soils at Fort Carson, Colorado

Step 1: Select four to eight species and their percent composition from Table 4. Example:

Species Selected	Percent Composition Selected
Desert wheatgrass	0.20
Pubescent wheatgrass	0.30
Western wheatgrass	0.40
Alfalfa	0.10

Step 2: Determine the percent pure live seeds (%PLS) of the seeds to be used. This is either already calculated and marked on shipping bags, or it can be calculated using percent germination and percent purity. Percent PLS can be calculated from the following formula:

%PLS = (% purity)(% germination)

Example:	% purity	x % germination	= %PLS
Desert wheatgrass	90	95	= 85.5
Pubescent wheatgrass	90	95	= 85.5
Western wheatgrass	90	95	= 85.5
Alfalfa	90	80	= 72.0

Step 3: Calculate the number of kilograms of seeds required to make up 1 kg of pure live seeds. The formula is derived as follows:

100 ÷ %PLS (from step 2) = number of kilograms required to make up 1 kg of pure live seeds

Example:

Desert wheatgrass	100 ÷ 85.5 = 1.17 kg
Pubescent wheatgrass	100 ÷ 85.5 = 1.17 kg
Western wheatgrass	100 ÷ 85.5 = 1.17 kg
Alfalfa	100 ÷ 72.0 = 1.39 kg

Step 4: Calculate the number of pure live seeds of each species required for each square meter of soil surface to be seeded using the formula below, given that the total number of pure live seeds per square meter desired is 270 seeds/m^2.

Table 11 (Cont'd)

(total number of seeds/m^2 desired)(percent composition of species) (given in Step 1) = number of seeds/m^2 of species

Example:

Desert wheatgrass	270 x 0.20 =	54 seeds/m^2
Pubescent wheatgrass	270 x 0.30 =	81 seeds/m^2
Western wheatgrass	270 x 0.40 =	108 seeds/m^2
Alfalfa	270 x 0.10 =	27 seeds/m^2
		270 seeds/m2 total

Step 5: Calculate the number of kilograms per hectare of pure live seeds for each species needed in order to provide the required number of pure live seeds per square meter (Step 4), using the calculation below (1 ha = 10,000 m^2).

(number of seeds/m^2 of species [given in Step 4]) (10,000 m^2/ha) ÷ (number of seeds per kg of each species [given in Species Description, Chapter 4] = kg/ha of species required)

Desert wheatgrass	54/m^2 x 10,000 m^2/ha	÷	400,000 seeds/kg	= 1.35 kg/ha
Pubescent wheatgrass	81/m^2 x 10,000 m^2/ha	÷	190,000 seeds/kg	= 4.26 kg/ha
Western wheatgrass	108/m^2 x 10,000 m^2/ha	÷	240,000 seeds/kg	= 2.25 kg/ha
Alfalfa	27/m^2 x 10,000 m^2/ha	÷	500,000 seeds/kg	= 0.54 kg/ha

rocky soils. These sites should be stabilized with straw or native hay mulch and tacked either with a mulch crimper or tackifier such as asphalt. Mulch should be applied at 2.5 to 4.5 MT/ha, and asphalt should be sprayed at a rate of 37 to 56 gal/ha. Military installations such as Forts Bliss and Irwin may find it more economical to use chemical tackifiers or other types of organic mulch materials because of the low availability and subsequent high cost of straw and native hay.

Areas disturbed once every 3 months to 2 years may be more economically treated by planting an agricultural grain crop for quick cover. These areas should be disked and then drill-seeded with the selected, appropriate grain. Heavy-duty, two-way disk equipment and agricultural grain drills will probably be the most effective equipment. Table 12 lists recommended grains and other species that will provide rapid erosion control for these disturbed sites. Use of grain crops will not be effective at Fort Irwin and should not be used; in extremely dry years, they will not be effective at Fort Bliss.

Use of forbs or woody plant species is generally not recommended at any western installation for revegetation of heavily used training areas or for stabilizing areas where vehicles have continuous access. Few forbs and no shrubs or succulents can withstand the pressures of tracked or wheeled traffic. Although some shrub and forb species may sprout from roots after being run over, repeated impacts will kill the regenerating root stock. Succulents will not sprout readily from roots once a tracked vehicle has run over them.

Table 12

Grain Crops and Other Species Useful for Stubble Mulch on Western Military Installations

Species	Seeding Rate (kg PLS/ha)
Perennial rye	5.5 - 11.0
Sudangrass	11.0 - 27.5
Sorghum	6.0 - 16.5
Smooth brome	11.0
Tall fescue	11.0 - 22.0
Timothy	5.5 - 11.0
Alfalfa	16.5
Green sprangletop	2.5
Barley	20.0 - 33.0
Oats	11.0
Winter wheat	20.0 - 33.0
Rye	5.0 - 11.0
German millet	25.0 - 45.0
Annual ryegrass	20.0 - 33.0

3 SELECTED PLANT SPECIES FOR USE IN REVEGETATION OF MILITARY TRAINING RANGES

This chapter provides detailed information on plant species that may be useful in stabilizing soil on western military installations. Species are alphabetized by their accepted common name within each lifeform group (grasses, forbs, and woody species). Each species is identified by both its common name and scientific name, with information provided on its distribution and characteristics. Basic data are given on the plant's adaptability to climate, mean annual precipitation (MAP) required, cold and drought tolerance, soil and site characteristics (pH, texture, salinity, and depth), and environmental factors (fire, grazing, and competition). Also included are procedures for establishing the plant, its uses, and its availability. Appendix A provides a list of the common and scientific names for plants and animals common to western installations.

The species list is not exhaustive, but represents plants that are used most commonly, are most easily obtained, or that show the greatest promise for success on military bases. It includes the most up-to-date information available on cultivars, hybrids, and imported species, and much information about native species adapted for use on disturbed western lands. Emphasis has been placed on erosion control, hardiness, adaptability, and stabilization ability. Appendix B lists sources of seed and nursery stock.

Six Army installations have been chosen to illustrate the revegetation techniques, using the various plants described: Fort Riley, KS; Fort Sill, OK; Fort Carson, CO; Fort Hood, TX; Fort Bliss, TX; and Fort Irwin, CA. These installations were chosen because they are major training facilities where the Army would most likely use revegetation to maintain natural resources and a viable training environment. The glossary defines the terminology used in this report.

Grasses

1. Alkali sacaton (Sporobolus airoides)

Distribution: Alkali sacaton ranges from eastern California, Washington, and Oregon, eastward to Montana, South Dakota, Nebraska, Kansas, Missouri, Oklahoma, and the western half of Texas (Hitchcock, 1950; Wasser, 1982)*.

Description: Alkali sacaton is a native, cool-season, C-3**, long-lived, perennial bunchgrass (Thornberg, 1982). It attains a height of 50 to 100 cm (Hitchcock, 1950). Growth begins in mid-spring, and plants mature from July through October. This grass is moderately palatable to livestock and provides some forage for wildlife and small mammals.

*Complete references are provided on pp 86-92.

**C-3 and C-4 refer to animals' ability to chemically obtain energy from C-3 carbohydrates or from C-4 carbohydrates, respectively.

Ecological Setting: This species is best adapted to deep, moist (Aldon, 1975b) soils with textures ranging from sands to clays (Thornberg, 1982; Wasser 1982). It does well in MAP zones of 20 to 50 cm (Thornberg, 1982). Sacaton is highly tolerant of saline and sodic soils and temporary flooding. It is moderately drought- and fire-tolerant and has a good tolerance for grazing (Thornberg, 1982; Wasser, 1982).

Uses: The species provides good erosion control in floodways and on salty and alkaline soils. Alkali sacaton is adapted for use at Forts Bliss, Carson, Riley, and Sill.

Establishment: Seeds drilled at the rate of 0.5 kg pure live seed (PLS)/ha, 0.6 cm deep are the minimum recommended for rangeland seedings (Wasser, 1982). Irrigation, fertilization, mulch, and soil surface manipulations (pits, furrows, or basins) help establish and protect seedlings from drought. Aldon (1975b) found that (a) soil water must be at least 14 percent; (b) 1-year-old, large seeds should be used; (c) mulching provides best results; and (d) at least 6 cm of rain or irrigation water is necessary within the first 5 days of planting. Eighty percent of seeds germinate in 5 to 10 days under optimum conditions (Hafenrichter, et al., 1968; Wasser, 1982). Seedling vigor is fair, and stands can be well-established after two or three growing seasons. There are 3,850,000 seeds/kg (Fulbright, et al., 1982), and seeds can be stored for 4 years (Knipe, 1969).

Availability Cultivars: There are no formal cultivar releases of alkali sacaton. However, Wilcox is used in Arizona, P-15616 is being tested in New Mexico, and PM-NO-264 is being tested in North Dakota.

2. Basin wildrye (Elymus cinereus)

Distribution: This species ranges from Minnesota to Washington, south to Colorado, New Mexico, and California (Harrington, 1979; Hitchcock, 1950).

Description: Basin wildrye is a native, C-3, cool-season, perennial bunchgrass that grows 75 to 200 cm high (Harrington, 1979; Shaw and Cooper, 1973). It has an extensive, fibrous root system with short rhizomes. Growth is initiated in the early spring, and plants mature in mid to late summer. Foliage is moderately palatable to livestock year-round (Vallentine, 1971).

Ecological Setting: Basin wildrye is best adapted to silty and claycy bottomlands and drainages (Thornberg, 1982; Vallentine, 1971). It is also found on sandy soils (Harrington, 1979) and is tolerant of alkaline and saline soils (Hafenrichter, et al., 1968; Wasser, 1982). This species is found in MAP zones between 30 and 50 cm (Watson, et al., 1980). Basin wildrye is moderately tolerant of drought, fire, grazing, and cold (Vallentine, 1971; Wasser, 1982). It is also a strong competitor.

Uses: Basin wildrye provides spring and fall pasture forage, cover for upland game birds, and is useful in soil stabilization (Plummer, et al., 1968; Thornberg, 1982). It is adapted to Forts Carson, Riley, and Sill and may be adapted to mesic areas of Fort Bliss.

Establishment: Pure stands can be established by drill-seeding at a rate of 5.5 to 6.5 kg PLS/ha (Echols and Cuany, 1974; Wasser, 1982), at 2.5 cm deep (Fulbright, et al., 1982). About 80 percent seed germination occurs under laboratory conditions (Stefferud, 1948). Seedling vigor and growth are moderate, and stands develop in 2 or 3 years (Wasser, 1982). There are 209,000 to 365,000 seeds/kg (Stefferud, 1948; Vallentine, 1971).

Availability/Cultivars: One cultivar, Magnar, is adapted to northern Utah, southern Idaho, and Nevada. Another cultivar, P-5797, is also available.

3. Bearded wheatgrass (Agropyron subsecondum).

Distribution: This wheatgrass ranges from Maine to West Virginia, westward to California, Arizona, and New Mexico (Hitchcock, 1950).

Description: Bearded wheatgrass is a native, short-lived, perennial, cool-season bunchgrass. It has a fibrous root system and attains a height of 50 to 100 cm (Hafenrichter, et al., 1968; Watson, et al., 1980). Foliage is moderately palatable to livestock and small mammals and of low palatability to deer.

Ecological Setting: This species is adapted to sandy, well-drained soils that have low fertility (Hafenrichter, et al., 1968; Hitchcock, 1950; Watson, et al., 1980). It is adapted to moderately alkaline to weakly acid soils (Plummer, 1977), and is moderately saline-tolerant (West, 1979). Bearded wheatgrass is found in MAP zones of at least 35 cm and is moderately drought-tolerant. Similarly, it is moderately tolerant of shade and has good grazing tolerance. It can be a moderate to aggressive competitor (Hafenrichter, et al., 1968; Plummer, et al., 1955).

Uses: This species can be used for soil stabilization and as a forage species (Plummer, 1977). Bearded wheatgrass is suited for testing at Forts Carson, Riley, and Sill.

Establishment: Seeds drilled 1.3 to 2.5 cm deep at rates of 5 to 10 kg PLS/ha will be sufficient to establish pure stands of this species. It has high germination capacity (95 percent), excellent vigor, and rapid growth (Hafenrichter, et al., 1968), indicating that stands could be mature in two growing seasons. There are 257,400 to 330,000 seeds/kg (Fulbright, et al., 1982).

Availability/Cultivars: There are no formal releases to date, but several informal cultivars may be available (Watson, et al., 1980).

4. Bermuda grass (Cynodon dactylon)

Distribution: Bermuda grass is found throughout the southern half of the United States and was introduced into the United States in Mississippi before 1820.

Description: This species is an introduced, warm-season, C-4, perennial sod-former (Humphrey, 1958). Bermuda grass has an extensive and dense root system. Aerial shoots generally do not exceed 30 cm. It is a preferred

forage grass for livestock because of its high nutrient content, hardiness, and palatability.

Ecological Setting: Bermuda grass is adapted to all soil textures, but does best on medium textures (sandy, silty, and loamy soils) (Fulbright, et al., 1982; Thornberg, 1982). This grass is salt-tolerant and is adapted to a pH range of 5.5 to 7.5 (Beard, 1973; Thornberg, 1982). It is generally found in MAP zones of 35 cm or more (Thornberg, 1982) and is not highly tolerant of drought or cold. It is tolerant of grazing, but not shade, and has high fertility requirements.

Uses: Bermuda grass is an excellent species for forage production and soil stabilization on critical areas, such as waterways and slopes. This species is adapted to Forts Hood, Riley, and Sill.

Establishment: This species can be established by seed, sprigs, or sod, depending on how rapidly an area needs to be stabilized. The seedbed should be well prepared and relatively smooth and free of debris. Seeding at 1.1 kg/ha covers 1 m^2 with more than 270 seeds. Seeding with legumes will reduce the need for fertilizer applications every few years. Germination capacity is 82 to 88 percent (Fulbright, et al., 1982), and there are 3,300,000 to 3,495,000 seeds/kg (AOSA, 1970; Thornberg, 1982). Sprigging in a moist, firm seedbed with rows no greater than 50 cm apart is generally recommended (USDA-SCS, 1976). Solid, spot, and strip sodding are useful techniques that can provide immediate erosion control. Spot and strip sodding partially overcome the expense of solid sodding. Fertilization is necessary for establishment and will be required every 2 to 4 years to maintain stands.

Availability/Cultivars: Seeds and transplanting material are widely available for many different cultivars.

5. Big bluegrass (Poa ampla)

Distribution: This species ranges from western portions of Washington and Oregon, through the northern half of Nevada to northern Arizona and New Mexico, and up to Montana (Harrington, 1979; Hitchcock, 1950).

Description: Big bluegrass is a native, C-3, cool-season perennial bunchgrass. It grows 60 to 120 cm high (Hitchcock, 1950), and has a well-developed, fibrous root system (Wasser, 1982). Growth begins in March or April, plants mature in July and August (Vallentine, 1971), and with good moisture, regrowth is possible in the fall (Vallentine, 1967). This species is nutritious year-round, and is moderately palatable to livestock (Vallentine, 1971). Foliage has good palatability to large and small mammals in spring and summer, but is only fair in the fall and winter (Plummer, et al., 1968). Game birds and songbirds eat the seeds.

Ecological Setting: Big bluegrass is adapted to sandy to clayey soil textures (Vallentine, 1971), and does best in sandy and silty soils (Thornberg, 1982). It is best adapted to neutral pHs and has poor salt tolerance (Vallentine, 1971). It is adapted to 27- to 50-cm MAP zones (Thornberg, 1982) and is moderately drought-tolerant (Vallentine, 1971). This bluegrass is highly cold-tolerant, moderately tolerant of grazing and shade,

and weakly to moderately tolerant of spring flooding (Plummer, et al., 1968; Vallentine, 1971; Wasser, 1982). The species is moderately competitive.

Uses: Big bluegrass is a good forage and soil stabilization species and also provides cover for upland game birds. It could be tested for use at Fort Carson.

Establishment: The technique of drilling seeds 1.2 to 2.0 cm deep (Fulbright, et al., 1982) at rates of 1.0 to 4.0 kg PLS/ha is recommended for establishing stands of big bluegrass (Vallentine, 1971; Wasser, 1982). About 50 to 80 percent of the seeds germinate in 10 to 28 days (Currie, 1967; Fulbright, et al., 1982; Plummer, et al., 1968). Vigor and growth is good (Plummer, et al., 1968), and stands can be fully established in two growing seasons when protected from grazing. Stored seeds remain viable for up to 5 years (Hull and Pearse, 1943), and there are 1,980,000 to 2,022,000 seeds/kg (Heady, 1975; Vallentine, 1971).

Availability/Cultivars: The cultivar Sherman is used in revegetation projects in the western United States.

6. Big bluestem (Andropogon gerardii)

Distribution: This species is found from western Montana down through northeastern Arizona, and eastward to the Atlantic coast (Hitchcock, 1950).

Description: Big bluestem is a native, warm-season, C-4, perennial, weak sodformer. Culms are 90 to 180 cm tall. Growth begins in mid-spring, and plants mature in September or October. This species is highly palatable to livestock through the growing season and is fair in winter (Vallentine, 1967). It is also used by small mammals and gamebirds.

Environmental Setting: Big bluestem is found on deep, fertile clay and silt loams in draws, and in subirrigated sites in 35- to 65-cm MAP zones (Thornberg, 1982). It is moderately tolerant of saline and alkaline soil conditions. Big bluestem has good tolerance of fire and cold and moderate tolerance of grazing, flooding, and shade (Wasser, 1982).

Uses: This species provides long-term erosion control, livestock forage, and cover for wildlife. It is adapted to Forts Carson, Hood, Riley, and Sill.

Establishment: Seeds should be drilled 0.6 to 2.5 cm deep at 5.5 to 9.0 kg PLS/ha (Wasser, 1982). Prechilled seeds germinate in 10 to 20 days under optimum conditions. Germination capacity is 50 to 60 percent (Fulbright, et al., 1982). Seedling vigor is good; however, 2 years is required for good stand establishment, which is enhanced by mulching and fertilization. There are 286,000 to 420,000 seeds/kg, and seeds can be stored for up to 3 years (Fulbright, et al., 1982).

Availability/Cultivars: Pawnee is the cultivar adapted for Nebraska ranges. Kaw is appropriate for use in Kansas and Oklahoma. Champ is adapted to Nebraska and Kansas (Thornberg, 1982).

7. Black grama (Bouteloua eriopoda)

Distribution: Black grama is a major species of semi-arid grasslands of Arizona, New Mexico, Texas, western Oklahoma, and southeastern Colorado (Hitchcock, 1950).

Description: This species is a native, warm-season, C-4, weakly sod-forming, perennial grass. Culms attains a height of 20 to 60 cm (Harrington, 1979; Hitchcock, 1950). Growth is initiated in late spring, and plants mature in the fall. It is highly palatable, and is nutritious summer through winter to livestock and many species of wildlife (Thornberg, 1982).

Ecological Setting: This species is found on well-drained sands and silts, but does poorly on clay soils (Thornberg, 1982). It is associated with shallow calcareous soils on mesas and on grassland flats. It is most commonly found in 23- to 46-cm MAP zones (Thornberg, 1982), but can survive in MAP zones of 10 to 23 cm. Black grama is drought-hardy if ungrazed, and is browse-resistant; however, it is susceptible to fire and is shade-intolerant (Wasser, 1982).

Uses: Black grama is a useful species for long-term erosion control and forage production. This species is adapted to Fort Bliss and may be useful at Forts Irwin and Carson.

Establishment: Drill-seeding 1.3 cm deep at rates of 1.0 to 4.0 kg PLS/ha is recommended (Stefferud, 1948; Wasser, 1982). This species has a low germination capacity of (20 percent) (Wheeler and Hill, 1957) and requires several days of good moisture for successful germination (Wasser, 1982). Therefore, supplemental water may be needed to establish good stands. There are 2,937,000 seeds/kg, and seeds remain viable for 3 or 4 years in storage (Wheeler and Hill, 1957).

Availability/Cultivars: The cultivar Nogal has excellent seedling vigor and good seed production. Sonora is suggested for southwest Arizona at elevations of 1050 to 1850 m.

8. Bluebunch wheatgrass (Agropyron spicatum)

Distribution: Bluebunch wheatgrass range extends from west Texas northward through western Colorado up to the western Dakotas, and westward to California, eastern Oregon, and Washington (Hitchcock, 1950; Wasser, 1982).

Description: This species is a native, cool-season, C-3, perennial bunchgrass. Culms reach 45 to 120 cm high (Beetle, 1977). Plant growth is begins in early spring, and plants become dormant in the summer. Regrowth occurs with fall rains. Bluebunch wheatgrass is moderately to highly palatable to livestock, small mammals, and deer year-round, and is eaten by antelope in the spring (Plummer, et al., 1955).

Ecological Setting: Bluebunch wheatgrass is commonly found on a wide soil texture spectrum, ranging from sandy to clayey soils. It does best on silty soils, but occasionally occurs on thin, gravelly soils. Bluebunch

wheatgrass is moderately tolerant of alkaline and weakly acidic soil (Plummer, 1977), but is intolerant of poorly drained sites. This species is found in MAP zones of 20 to 88 cm (Wasser, 1982); it is highly tolerant of drought and cold, but moderately tolerant of shade, grazing, fire, and salinity (Wasser, 1982; Watson, et al., 1980). The species is low to moderate in competitiveness (Watson, et al,. 1980).

Uses: Bluebunch wheatgrass will provide long-term erosion control and forage for big game and livestock. This species may be useful at Fort Carson.

Establishment: Seeding at depths of 0.6 to 2.0 cm with 5.6 to 11 kg PLS/ha yields best results. Prechilled seeds germinate in 14 days under optimum conditions (Wasser, 1982). Germination capacity is about 90 percent (Fulbright, et al., 1982). Seedling vigor is fair, but competition from annuals and more vigorous perennial species will reduce production of establishing stands. The growth rate is moderate (Plummer, 1977), and stands will require 2 to 3 years to establish completely. It is slightly responsive to fertilization and irrigation. There are 209,000 to 330,000 seeds/kg (Fulbright, et al., 1982), and stored seeds remain viable for 5 years (Hull and Pearse, 1943).

Availability/Cultivars: Some taxonomists consider beardless wheatgrass (Agropyron inerme) to be an awnless variety of bluebunch wheatgrass. Seeds of bluebunch wheatgrass are readily available; however, Whitmar beardless wheatgrass is the only released cultivar known for either grass.

9. Blue grama (Bouteloua gracilis)

Distribution: This species ranges from southern California and Nevada across to east Texas and Arkansas, extending north into Canada, and east of the Mississippi River in the United States (Hitchcock, 1950).

Description: Blue grama is a native, warm-season, C-4, perennial, sod-forming bunchgrass that grows to 15 to 60 cm high (Harrington, 1979). Growth begins in midspring, and plants mature in summer through fall. The foliage is highly nutritious and palatable to livestock and wildlife throughout the year (Thornberg, 1982; Wasser, 1982).

Ecological Setting: Blue grama grows on sandy to clayey soils (Thornberg, 1982). It is moderately tolerant of saline and acidic conditions, but is also common on alkaline sites. This species is found in 20- to 50-cm MAP zones (Thornberg, 1982). It has excellent tolerance for cold, drought, and grazing, but is intolerant of flooding and shade, and has variable fire tolerance.

Uses: This species is good for long-term erosion control, and it provides forage production for livestock. Blue grama is adapted to Forts Bliss, Carson, Hood, Riley, and Sill.

Establishment: The species should be drill-seeded 0.6 to 1.3 cm deep at rates of 1.0 to 3.5 kg PLS/ha (Wasser, 1982). Germination capacity is 60 to 75 percent (Fulbright, et al., 1982), with seeds germinating in 7 days under optimum field conditions; however, seedling vigor is weak (Wasser,

1982). Seedlings are susceptible to drought, and irrigation may be needed to ensure establishment. This species also responds positively to nitrogen applications. Stand development is slow, regardless of cultural practices used. There are 770,000 to 1,570,000 seeds/kg, and seeds can be stored for 4 to 8 years without a great loss in viability (Fulbright, et al., 1982).

Availability/Cultivars: Lovington is the only improved cultivar released to date. It is appropriate for use on upland sites that have medium- to fine textured soils, such as eastern New Mexico, northwest Texas, and southeast Colorado. Native collections are available from commercial dealers.

10. Blue panic grass (Panicum antidotale)

Distribution: This species is found in southern portions of New Mexico, Arizona, and Texas, as well as parts of Oklahoma and California (Hitchcock, 1950; Thornberg, 1982).

Description: Blue panic grass is an introduced, C-4, warm-season, perennial sod-former. It is strongly rhizomatous and grows to heights of 120 to 180 cm. Growth begins in mid-spring, with maturity in the fall. The foliage is nutritious (Jordan, 1981) and palatable to both livestock and wildlife from spring through early fall (Vallentine, 1971).

Ecological Setting: This species is mostly adapted to silty and clayey soils, although it is found on moist, sandy sites (Thornberg, 1982). It prefers fertile, well-drained sites with adequate moisture (Jordan, 1981; Thornberg, 1982). It is moderately salt-tolerant (Vallentine, 1971) and is found in 27- to 50-cm MAP zones (Thornberg, 1982). Blue panic grass is moderately tolerant of drought and grazing (Vallentine, 1971), but intolerant of temperatures below 28°C (Thornberg, 1982).

Uses: This species has been used for dryland and irrigated pastures in the southwest (Thornberg, 1982) and could be tested for special-use areas at Forts Bliss, Irwin, Hood, and Sill.

Establishment: Stands should be established by seeding at rates of 1 to 2 kg PLS/ha, 1.3 cm deep. Vigor, growth, and stand development are slow (Jordan, 1981). There are 1,445,000 seeds/kg (Vallentine, 1971).

Availability/Cultivars: One cultivar (A-130) has been formally released. The cultivar T-15327 has been released informally and is reported to have better cold tolerance (Jordan, 1981).

11. Boer lovegrass (Eragrostis curvula var. conferta)

Distribution: This species is found in parts of Oklahoma, Texas, New Mexico, and Arizona.

Description: Boer lovegrass is an introduced, warm-season, C-4, perennial bunchgrass (USDA-SCS, 1972). Culms grow 60 to 90 cm high and have an extensive, deep, fibrous root system. Growth begins in early spring with maturity by late fall (Jordan, 1981). Young foliage is palatable and

nutritious to livestock (USDA-SCS, 1972; Vallentine, 1971), but the species offers little value to wildlife.

Ecological Setting: Boer lovegrass is best adapted to sandy and clay loams, but can be adapted to a wide range of other textures (USDA-SCS, 1972). It is moderately saline-tolerant (Vallentine, 1971), but is not alkaline-tolerant (USDA-SCS, 1972). This species is best adapted to 27- to 38-cm MAP zones. It is tolerant of drought and grazing and is aggressively competitive in lowland sites; however, it has poor tolerance for cold (Jordan, 1981; USDA-SCS, 1972; Vallentine, 1971).

Uses: This species is good for erosion control and forage production, and also provides cover for small mammals. It is adapted for use at Forts Bliss, Hood, and Sill, and could be tested at Fort Irwin.

Establishment: Seeds should be broadcast and covered or drilled to a depth of less than 1.2 cm at a rate of 0.6 to 1.1 kg PLS/ha (Jordan, 1981; USDA-SCS, 1972). Pitting and furrowing on clean seedbeds will improve stand establishment. Stands should be protected from training use for 2 years (USDA-SCS, 1972). There are 6,428,400 seeds/kg (Vallentine, 1971).

Availability/Cultivars: The cultivars A-84 and Cataline are available and have been released in Arizona.

12. Buffalograss (Buchloe dactyloides)

Distribution: Buffalograss is an important species of the shortgrass prairie, ranging from Minnesota through Montana to Iowa, south to Texas, and into portions of New Mexico and Arizona (Harrington, 1979; Hitchcock, 1950).

Description: This species is a stoloniferous, native, warm-season, perennial, sod-forming grass (Thornberg, 1982). It is short (5 to 10 cm) (Hitchcock, 1950) and grows throughout the summer. Foliage is nutritious and palatable to livestock and other wildlife year-round.

Ecological Setting: Buffalograss is adapted to medium- and fine-textured soils (Thornberg, 1982), but is most common on clay flats of moderate depth. It has good drought and salinity tolerance, is moderately flood-tolerant, and is found in MAP zones of between 25 and 50 cm (Thornberg, 1982). It is tolerant of grazing, fire, and cold, but does poorly in shady habitats. It is moderately competitive.

Uses: This grass is useful for long-term erosion control and forage production. It is adapted to Forts Carson, Hood, Riley, and Sill, and may be useful at Fort Bliss.

Establishment: Seeds should be drilled 1.3 to 2.5 cm deep at rates of 11 to 33 kg PLS/ha (USDA-SCS, 1978). Seedling vigor and growth is moderate, and germination capacity ranges between 40 and 70 percent (Fulbright, et al., 1982). Supplemental water will improve establishment success and rate of plant growth, especially in dry years. There are about 93,000 seeds/kg (Heady, 1975), and seed can be stored for up to 5 years (Kneebone, 1960).

Availability/Cultivars: Two common cultivars (Sharps Improved and Texoka), are adapted to Texas, Oklahoma, and Kansas (Thornberg, 1982).

13. Buffelgrass (Cenchrus ciliaris)

Distribution: This species ranges from south Texas and the Gulf Coast to southwest Arizona (Thornberg, 1982).

Description: Buffelgrass is an introduced, C-4, warm-season, sod-forming grass that has a bunchgrass-like appearance. It attains a height of 75 to 105 cm, and has a deep, extensive root system (Jordan, 1981). Growth begins in early spring, and green growth is maintained through November (Jordan, 1981; USDA-SCS, 1981). It is not considered a palatable species (Thornberg, 1982).

Ecological Setting: Buffelgrass is adapted to sandy and loamy soils of low fertility (Jordan, 1981; Thornberg, 1982) and is moderately salt-tolerant (Jordan, 1981). It is adapted to 30- to 50-cm MAP zones and has excellent drought tolerance (Jordan, 1981; Thornberg, 1982). This species is tolerant of grazing, but is not winter-hardy.

Uses: Buffelgrass shows promise for soil stabilization in arid regions of the southwest United States. It could be tested at Forts Bliss, Hood, and Irwin to identify adaptability and establishment procedures.

Establishment: Broadcast seeding at 1.1 to 3.5 kg/ha is recommended. Germination vigor and growth are reported to be good (Jordan, 1981; Thornberg, 1982). There are about 1,892,000 seeds/kg.

Availability/Cultivars: Seeds are limited in availability. Releases include Higgi's, Llano, and Nueces. Nueces has superior cold tolerance.

14. Caucasian bluestem (Bothriochloa caucasica)

Distribution: This species is found in eastern New Mexico and Colorado, and eastward throughout the Texas Panhandle, Oklahoma, Kansas, and Missouri (Wasser, 1982).

Description: Caucasian bluestem is an introduced, warm-season, C-4, perennial bunchgrass (Gould and Box, 1965). Culms grow 60 to 120 cm high. Growth begins in late spring, and plants mature in early fall. This species is less palatable than other introduced bluestems and native bluestems.

Ecological Setting: The species is commonly found on fertile loams and clays, but does poorly on sands (Launchbaugh, 1971; Thornberg, 1982). It is moderately tolerant of saline, alkaline, and acid soil conditions, and is adapted to MAP zones of 40 to 65 cm (Wasser, 1982). Thornberg (1982) recommends its use in MAP zones of 46 cm or more. It is tolerant of drought and fire and is moderately tolerant of grazing (Wasser, 1982).

Uses: This bluestem species is excellent for long-term erosion control and provides cover for birds. Because of its low palatability, it will be difficult to manage if mixed with more palatable species (Wasser, 1982)

that are conducive to grazing by wildlife or livestock. Caucasian bluestem is adapted to Forts Carson, Hood, Riley, and Sill.

Establishment: Caucasian bluestem should be drill-seeded 0.6 to 1.3 cm deep at rates of 3.0 to 5.0 kg PLS/ha (Wasser, 1982). Prechilled seeds will germinate in 28 days under laboratory conditions (Wasser, 1982). Seedling vigor is good, and stands can be used by the second growing season. Mulching and fertilization aid in stand establishment. This species may require intensive management to maintain vigor. There are 946,000 seeds/kg (Thornberg, 1982), and the seeds probably have storage longevity similar to that of other bluestem species.

Availability/Cultivars: There are no cultivar releases in the United States. Problems with seed handling and seed shortages make the availability of this species limited.

15. Cochise lovegrass (Eragrostis lehmanniana, E. trichophora)

Distribution: This species is generally found in parts of New Mexico, Arizona, west Texas, and southern California (USDA-SCS, undated).

Description: Cochise lovegrass is an introduced, hybridized, warm-season, C-4, perennial bunchgrass. Plants grow to 120 cm high (Jordan, 1981; USDA-SCS, undated). The species has an extensive, fibrous root system, although it has been reported as occasionally having stolons (USDA-SCS, undated). Growth begins in the spring, with plants maturing in late summer and fall. Cochise is generally considered more productive on wet sites and is of higher palatability than Lehmann lovegrass (Jordan, 1981).

Ecological Setting: Cochise lovegrass is adapted to sandy through silt loam textures in 25- to 50-cm MAP zones (Jordan, 1981; USDA-SCS, undated). It is tolerant of grazing and drought, but intolerant of cold (Jordan, 1981). This species is similar in adaptation to Lehmann lovegrass, except that its productivity is greater at higher elevations, it is easier to establish, and it is more persistent than Lehmann lovegrass.

Uses: This species should be used for erosion control and forage production in mixtures with other species. It is adapted for Fort Bliss and could be tested at Fort Irwin.

Establishment: Seeds should be broadcast at rates of 1.1 kg PLS/ha or drilled no deeper than 0.6 to 1.2 cm at 0.3 to 0.6 kg PLS/ha (USDA-SCS, undated). Pitting, furrowing, and irrigation will improve stand establishment. Cochise lovegrass should not make up more than 25 percent of any seed mixture unless rapid cover is needed and diversity of climax vegetation is not desired (USDA-SCS, undated).

Availability/Cultivars: Seeds are available commercially, but no cultivars have been developed.

16. Desert wheatgrass (Agropyron desertorum)

Distribution: Desert wheatgrass is found in the Northern Great Plains, Intermountain Region, Great Basin, and western Oregon and Washington (Hitchcock, 1950).

Description: Desert wheatgrass is an introduced, cool-season, C-3, long-lived, perennial bunchgrass (Thornberg, 1982). It has a deep fibrous root system and grows 25 to 100 cm tall (Hitchcock, 1950). Growth begins in early spring, with maturity in early summer. Some regrowth occurs in the fall. Foliage is moderately palatable to livestock and small mammals, but less palatable to big game.

Ecological Setting: Desert wheatgrass is commonly found on silty and clayey soils and to a lesser degree on sandy to clay soils in MAP zones of 20 to 40 cm (Fulbright, et al., 1982; Thornberg, 1982), but has been reported in MAP zones as low as 13 cm (Lang, et al., 1975). Hafenrichter, et al., (1968), report that desert wheatgrass is generally found on medium- and coarse-textured soils of moderate alkalinity. It has excellent drought, saline (5 to 10 mmhos/cm), and cold tolerance (Watson, et al., 1980). Under proper management, stands are tolerant of grazing. Desert wheatgrass is fire-resistant and highly competitive (Shaw and Cooper, 1973).

Uses: This species has been used extensively in the western United States to lengthen grazing seasons into early spring and stabilize disturbed soils. Desert wheatgrass is adapted to Forts Carson, Riley, and Sill.

Establishment: Seeds drilled 1.3 to 2.0 cm deep at 5.5 to 16.5 kg PLS/ha on a firm seedbed are recommended for establishing pure stands of desert wheatgrasses. Mulch and fertilization enhance stand development. Seed germination of 69 percent in 7 days was reported by Wolff (1951). Stands are well-developed by the end of the second growing season if they are protected from grazing (Hafenrichter, et al., 1968). There are 400,000 to 455,000 seeds/kg (AOSA, 1978), and viability of seeds has been good after 12 years in storage (Hafenrichter, et al., 1968).

Availability/Cultivars: Nordan was released from North Dakota, and Summit was released from western Canada (Thornberg, 1982). Fairway crested wheatgrass (Agropyron cristatum (L.) Gaertn.) and Siberian wheatgrass (Agropyron sibiricum (Willd.) Beauv.) are similar species in the crested desert wheatgrass complex (Hitchcock, 1950). Fairway crested wheatgrass is weakly rhizomatous. Compared to desert wheatgrass, it is more cold- and drought-hardy, less fire-resistant, and easier to establish (Wasser, 1982; Watson, et al., 1980). Siberian wheatgrass is better for use in droughtier areas than crested or desert wheatgrasses, and grows later into the summer. Several cultivars of Fairway crested wheatgrass and one cultivar of Siberian wheatgrass are available in the United States.

17. Galleta (Hilaria jamesii)

Distribution: This species ranges from western Texas through Oklahoma, Colorado, Utah, New Mexico, Arizona, southern Nevada, and Wyoming (Hitchcock, 1950).

Description: Galleta is a native, warm-season, C-4, sod-forming grass. Culms are 15 to 60 cm high (Harrington, 1979). Growth begins in spring when moisture is available, and plants mature from early summer through October, depending on moisture (Wasser, 1982). Foliage is palatable to livestock during the growing season, but unpalatable when it reaches maturity (Thornberg, 1982). It has little wildlife value.

Ecological Setting: Galleta is commonly found on silty and clayey soils and on well-drained sands and fractured rocks in western Colorado (Thornberg, 1982). It has a low to moderate tolerance of saline and alkaline sites. Galleta occurs in MAP zones of 25 to 50 cm (Thornberg, 1982). It is tolerant of drought, grazing, and cold, moderately fire-tolerant, and has limited shade tolerance (Thornberg, 1982; Wasser, 1982). It is not compatible with grama grasses because it is more competitive and less palatable.

Uses: This species will provide erosion control and livestock forage on xeric grasslands. Galleta is adapted for use at Forts Bliss and Carson and may be adapted to Fort Irwin.

Establishment: Galleta should be drill-seeded 1.3 to 2.5 cm deep (Wasser, 1982) at rates of 5.5 to 7.0 kg PLS/ha. Furrows, basins, and pits irrigation, coupled with mulching aid stand establishment in arid areas. Seeds germinate in 14 to 30 days, with germination capacity at 65 to 80 percent (Fulbright, et al., 1982). Seedling growth is slow, so stands may require 2 or 3 years to become fully established; however, once established, seedlings are drought- and cold-hardy. There are 352,000 to 396,000 seeds/kg (Fulbright, et al., 1982).

Availability/Cultivars: The cultivar Viva was released in 1979 in New Mexico; however, seed availability may be limited.

18. Green needlegrass (Stipa viridula)

Distribution: This species ranges from Wisconsin and Illinois to Montana and eastern Wyoming, plus central Colorado and northern portions of Arizona and New Mexico (Wasser, 1982).

Description: Green needlegrass is a native, C-3, cool-season, perennial bunchgrass. It attains a maximum height of 50 to 100 cm (Harrington, 1979) and has a deep, fibrous root system (Smoliak, et al., 1972). Growth begins in March, plants mature in July, and regrowth is possible if sufficient moisture is available (Vallentine, 1967). The foliage is palatable to livestock (Plummer, et al., 1968; Vallentine, 1971) and moderately palatable to wildlife (Plummer, et al., 1968). Its seeds are eaten by songbirds and rodents.

Ecological Setting: This needlegrass species is adapted to most soils of various textures (Vallentine, 1971), although it prefers clays (Wasser, 1982). It is moderately tolerant of alkaline soils (Wasser, 1982; Watson, et al., 1980) and has poor saline tolerance (Vallentine, 1971). The species is found in MAP zones of 25 to 50 cm, but does best in MAP zones that exceed 37 cm (Thornberg, 1982). Green needlegrass is moderately tolerant of drought (Vallentine, 1971), grazing (Plummer, et

al., 1968), and cold, has variable tolerance of fire, and has poor shade tolerance (Wasser, 1982). This species is moderately competitive.

Uses: Green needlegrass provides forage and erosion control and has good wildlife values. It is adapted for use at Forts Bliss and Carson and could be tested at Fort Riley.

Establishment: Seeding at rates of 4.8 to 5.5 kg PLS/ha (Vallentine, 1971; Wasser, 1982), 2.5-cm deep (McWilliams, 1955) has been suggested for establishing pure stands. McWilliams (1955) tested seeding rates of between 4.4 and 13 kg PLS/ha and found no difference in final establishment. However, higher seeding rates produced denser initial stands more rapidly than low rates. Prechilling seeds is recommended. Seed germination varies between 25 and 80 percent (Fulbright, et al., 1982); seedling vigor is good, but growth is slow (Wasser, 1982). Fertilization and weed control aids stand establishment. Seeds are viable for up to 8 years in storage (McWilliams, 1950), and there are 370,000 (AOSA, 1978) to 400,000 seeds/kg (Heady, 1975).

Availability/Cultivars: Three commonly used cultivars are Green Stipagrass, Lodorm, and Mandan 2611.

19. Green sprangletop (Leptochloa dubia)

Distribution: Green sprangletop is found throughout Texas, Oklahoma, southern New Mexico, and southern Arizona (Hitchcock, 1950; Thornberg, 1982).

Description: This species is a native, warm-season, C-4, short-lived, perennial bunchgrass. Culms are 50 to 120 cm tall (Hitchcock, 1950; Wasser, 1982). Growth usually begins in April, but may be delayed until summer rains have increased soil moisture. Foliage is highly palatable to livestock but is of moderate to low palatability to wildlife. Songbirds eat the seeds (Thornberg, 1982; Wasser, 1982).

Ecological Setting: This is a pioneer species on disturbed sites and is generally found on well-drained rocky hills and canyons (Thornberg, 1982). Green sprangletop is found in MAP zones of 25 to 50 cm (Thornberg, 1982). It has been successfully seeded on deep sands and clays, although it is not naturally found on soils with these textures. It tolerates weakly saline and moderately alkaline sites. Green sprangletop is highly tolerant of drought and fire, moderately tolerant of cold temperatures and grazing, and intolerant of shade (Wasser, 1982).

Uses: This species is a good, temporary erosion control plant. Its rapid growth will control erosion quickly, yet it does not competitively exclude slower-developing, long-lived perennials. It has been suggested that it be seeded in pure stands for use as a hay crop (USDA-SCS, 1976). If the species is used for permanent erosion control (more than 3 years), then it should not be seeded alone. Stands tend to weaken and die out after a few years. Green sprangletop is adapted for use at Forts Hood and Sill and could be tested at Forts Bliss, Carson, and Riley.

Establishment: Drill-seeding at rates of 0.5 to 2.5 kg PLS/ha, 1.3 to 2.0 cm deep is recommended. Mulching, irrigation, moisture-conserving practices

(furrowing and pitting), and fertilization all enhance establishment. Seed quality can be high (72 percent germination), and seeds retain good viability when stored. There are 1,183,600 seeds/kg.

Availability/Cultivars: There are no formally released cultivars, and seed availability is limited. Marfa is an informal release.

20. Indian ricegrass (Oryzopsis hymenoides)

Distribution: This species ranges from the Dakotas south through western Nebraska, Kansas, Oklahoma, and Texas, and westward to the mountains of California, Oregon, and Washington (Hitchcock, 1950).

Description: Indian ricegrass is a native, perennial bunchgrass that has great ecotypic variation. It has been classified as both a warm-season and cool-season species. Plants are 20 to 70 cm high (Harrington, 1979; Wasser, 1982). Growth begins in the spring, with plants maturing in the summer and some regrowth in the late summer and fall. Foliage is highly palatable and nutritious to livestock year-round (Thornberg, 1982) and is moderately palatable to deer during the spring (Wasser, 1982). Seeds are eaten by gamebirds, songbirds, and small mammals.

Ecological Setting: Indian ricegrass is a pioneer species on disturbed sites and grows well on coarse sands and sandy to silty soils that are welldrained (New Mexico State University, Cooperative Extension Service, 1978). It occurs in MAP zones of 15 to 50 cm (Wasser, 1982). It is cold-hardy, tolerant of grazing, drought, and fire, and tolerant of slightly saline and alkaline sites (New Mexico State University, Cooperative Extension Service, 1978; Plummer, et al., 1968; Wasser, 1982). This grass is a moderate competitor, but is difficult to establish in mixtures with other grass species.

Uses: This species is a good forage producer. Its fibrous roots serve to build soils and reduce erosion. Indian ricegrass is adapted for use at Forts Bliss and Carson and could be tested at Fort Irwin.

Establishment: Indian ricegrass should be seeded 4 to 10 cm deep at rates of 4 to 9 kg PLS/ha (Hafenrichter, et al., 1968; Wasser, 1982). Mulching and irrigation help establish this species; however, it has shown limited response to fertilization (New Mexico State University Cooperative Extension Service, 1978). Seeds require 50 to 60 days to germinate due to dormancy problems. Prechilling for 4 weeks or use of acid or mechanical scarification techniques helps break dormancy. McDonald (1976) reported 86 percent germination in 7 days. Seedling vigor is fair; however, stands develop slowly and may require several years to develop. There are 300,000 to 355,000 seeds/kg (Fulbright, et al., 1982), and stored seeds retain good viability for 14 years (Hafenrichter, et al., 1968). It is best to use seeds that are at least 1 year old (Robertson and Pearse, 1943).

Availability/Cultivars: Seeds are readily available. Nezpar is a cultivar for the Intermountain West, while Paloma is best for southern Colorado through Arizona and New Mexico (Thornberg, 1982).

21. Inland saltgrass (Distichlis stricta)

Distribution: This species occurs throughout the western half of the United States (Harrington, 1979; Hitchcock, 1950).

Description: Inland saltgrass is a native, perennial, C-4, warm-season grass. It has a maximum height of 10 to 38 cm and is a sod-former with strong rhizomes (Institute for Land Rehabilitation, 1978; Thornberg, 1982). It is of moderate palatability to livestock due to its rough leaf material and salt content (Gay and Dwyer, 1965). This saltgrass maintains green forage longer than other grasses during drought (Humphrey, 1958).

Ecological Setting: Inland saltgrass is found on medium- to fine-textured soils that are poorly drained (Stefferud, 1948). It is both alkaline- and saline-tolerant (Stefferud, 1948; Thornberg, 1982). This species is best adapted to MAP zones of 38 to 50 cm, but has been found in zones of 25 to 37 cm in mesic drainages (Thornberg, 1982). Inland saltgrass is tolerant of drought and grazing, is moderately cold-tolerant, and is competitive.

Uses: Inland saltgrass is adapted for use as a soil-stabilizing species on poorly drained soil with high salt content. It could be tested at Forts Bliss, Carson, and Irwin.

Establishment: Inland saltgrass has not been widely planted and generally is not used in experimental revegetation studies. Sprigging appears to be a more common practice than seeding. A firm, well-prepared, moist seedbed will enhance the success of sprigging.

Availability/Cultivars: Plant and seed materials are not commercially available, and no cultivars have been released to date.

22. Intermediate wheatgrass (Agropyron intermedium)

Distribution: This species ranges through the northern Great Plains, Great Basin, and Intermountain West (Wasser, 1982).

Description: Intermediate wheatgrass is an introduced, cool-season, C-3, sod-forming grass that grows 60 to 120 cm tall (Cronquist, et al., 1977; Thornberg, 1982). Growth begins in early spring, with plants maturing in early summer. There is late summer and fall regrowth if fall precipitation occurs. Foliage is palatable to livestock during the growing season, but decreases to moderate palatability in the winter. It is of moderate palatability to deer and small mammals throughout the year.

Ecological Setting: Intermediate wheatgrass is adapted to well-drained sandy to clayey soils with relatively high fertility and moisture levels (Wasser, 1982; Watson, et al., 1980). It is best adapted to nonsaline and neutral soils (Wheeler and Hill, 1957), but can withstand weakly acidic, basic, and moderately saline sites (Wasser, 1982; Watson, et al., 1980). It occurs in 25- to 50-cm MAP zones (Wasser, 1982). However, Plummer, et al. (1968), concluded that this species needs a minimum of 28 cm mean annual precipitation. It is moderately drought- and cold-hardy and highly tolerant of fire. It is moderately shade-tolerant, survives spring flooding, and is moderate to high in competitiveness (Watson, et al., 1980).

Uses: This species has been used for livestock grazing and soil stabilization but requires good grazing management, fertilization, and occasional irrigation to maximize forage and growth (Smoliak, et al., 1972; Wasser, 1982). Intermediate wheatgrass is adapted for use at Forts Carson, Riley, and Sill.

Establishment: Seeds should be drilled 1.3 to 2.5 cm deep at 5.5 and 16.5 kg PLS/ha to establish pure stands (Echols and Cuany, 1974; Wasser, 1982). Between 80 to 90 percent of seeds germinate in 7 to 28 days (Fulbright, et al., 1982). Vigor and growth of seedlings are good and stands can fully develop in 2 years. This species responds favorably to mulch, fertilization, and irrigation. There are 100,000 to 220,000 seeds/kg (Fulbright, et al., 1982), and good viability has been reported after 6 to 10 years in storage (Canode, 1972; Hafenrichter, et al., 1968).

Availability/Cultivars: Seeds are readily available and many cultivars have been released, including Amur from New Mexico; Oahe, a South Dakota sod-forming release; Slate from Nebraska; and Tegmar, a dwarf sod-former release from Idaho.

23. Kentucky bluegrass(Poa pratensis)

Distribution: This species is found throughout the United States (Hitchcock, 1950).

Description: Kentucky bluegrass is an introduced, C-3, cool-season, perennial, sod-forming grass. It grows to 30 to 100 cm tall (Hitchcock, 1950) and has a shallow root system (Watson, et al., 1980). It begins growing in March and goes dormant in hot dry weather. Foliage of this bluegrass is highly palatable to livestock in the growing season and moderately palatable to wildlife (Watson, et al., 1980).

Ecological Setting: Kentucky bluegrass is common on sandy to clayey soils (Heady, 1975). It is also found on shallow (Hafenrichter, et al., 1968) and poorly drained soils (Vallentine, 1971) whose pHs range from 5.8 to 8.2 (Wheeler, 1950). It has low tolerance for salinity and drought (Elliot and Bolton, 1970), and is found in MAP zones of 50 to 130 cm. It is tolerant of grazing, trampling, and cold and is a good competitor once established; however, it has poor shade tolerance (Bennet, et al., 1978; Watson, et al., 1980).

Uses: This species is a good erosion control and forage plant in mesic areas. Kentucky bluegrass can be used at Forts Carson, Riley, and Sill.

Establishment: Seeding at rates of 1.0 to 3.5 kg PLS/ha (Wasser, 1982), 0.6 cm deep (Rogler, et al., 1961) is recommended. Germination capacity is 50 to 65 percent (Fulbright, et al., 1982), and seedling vigor and growth are fair and slow, respectively. Stands will require several years to mature fully. Irrigation and low fertilization rates will help establishment. There are 2,250,000 to 4,754,000 seeds/kg (AOSA, 1978; Heady, 1975), and seeds should not be stored longer than 4 years (Garman and Vaughn, 1916).

Availability/Cultivars: There are 21 released cultivars for the United States, and seeds are readily available (Wasser, 1982).

24. Lehmann lovegrass (Eragrostis lehmanniana Nees.)

Distribution: This species is found in Arizona, New Mexico, western Texas, and Oklahoma (Hitchcock, 1950).

Description: Lehmann lovegrass is an introduced, warm-season, C-4, bunchy sod-former that grows 30 to 80 cm tall (Hitchcock, 1950; Thornberg, 1982). Growth begins in the spring, with plants maturing in the summer. Foliage is palatable to livestock from spring through fall, but has little value to wildlife.

Ecological Setting: Lehmann lovegrass is best adapted to sandy and silty textures (Thornberg, 1982). It is not cold-tolerant (to 10 C only), but is exceptionally tolerant of drought (Jordan, 1981). While Lehmann lovegrass is supposed to be adapted only to 25- to 38-cm MAP zones (Jordan, 1981), it has been reported to occurr in MAP areas of 18 to 24 cm (Thornberg, 1982). Plants are killed by fire, but seedling establishment following fire (particularly in wet years) indicates only temporary herbage reduction (Wright and Bailey, 1980).

Uses: Lehmann lovegrass provides long-term erosion control, forage for livestock, and cover for nongame birds. This species is adapted for use at Fort Bliss and could be tested at Fort Irwin.

Establishment: Seeding at about 1 to 2 kg PLS/ha at 0.6 to 1.3 cm deep is recommended. Seeds germinate rapidly, and seedling vigor is excellent. Use of mulches and moisture-conserving techniques is advisable. There are 14,300,000 seeds/kg (Jordan, 1981).

Availability/Cultivars: A-68 is a drought-tolerant cultivar released in 1950. Puhumima and Kuivata were released more recently for improved seed production and drought hardiness.

25. Little bluestem (Schizachyrium scoparium)

Distribution: This species occurs from Montana, south through Arizona, and east to the Appalachian Mountains (Hitchcock, 1950).

Description: Little bluestem is a native, warm-season, C-4, perennial bunchgrass. Culms are 30 to 180 cm tall (Wasser, 1982). Growth begins in the spring, with plants maturing in the fall. Palatability to livestock is good in early summer but declines to poor in winter. Palatability to deer and other big game mammals is fair.

Ecological Setting: This species is found on sandy to clayey soils (Thornberg, 1982), but does best on silty soils, limey uplands, and calcareous soils (Wasser, 1982). It has low fertility requirements and grows in MAP zones of 25 to 100 cm, but does best with 50 cm or more of precipitation (Wasser, 1982). Little bluestem is tolerant of cold and fire and moderately tolerant of drought and shade.

Uses: Little bluestem is a good species selection for long-term erosion control and livestock forage production. Seeds are eaten by some wildlife species, and plants provide cover for ground-nesting birds. This species is adapted for use at Forts Carson, Hood, Riley, and Sill.

Establishment: Seeds should be planted 0.6 to 2.0 cm deep at rates of 2.8 to 5.0 kg PLS/ha (Wasser, 1982). Soil Conservation Service guidelines suggest rates of 9 to 22 kg PLS/ha in Kansas (USDA-SCS, 1978). About 30 to 60 percent of seeds germinate in 7 to 30 days (Fulbright, et al., 1982), and seedling vigor is weak (Wasser, 1982). Vigorous stands may require 3 years of protection to ensure stability. There are 560,000 to 835,000 seeds/kg, and stored seeds maintain their viability for 3 years (Fulbright, et al., 1982). However, best germination occurs with 1-year-old seeds (Robocker, et al., 1953).

Availability/Cultivars: Aldous is the best cultivar in Kansas, particularly in the Kansas Flinthills. Blaze and Camper are adapted to Nebraska sites. Cimmaron is adapted to the Texas and Oklahoma panhandles, southwest Kansas, and southeastern Colorado. Pastura is adapted to the higher elevations of New Mexico, the Texas and Oklahoma panhandles, and southeastern Colorado (Thornberg, 1982).

26. Mountain brome (Bromus marginatus)

Distribution: This species is found from the Pacific Coast to Montana, South Dakota, and Iowa, as well as portions of Arizona, New Mexico, and western Kansas (Wasser, 1982).

Description: Mountain brome is a native, cool-season, C-3, perennial grass. It has a deep, fibrous root system and a maximum height of 30 to 125 cm (Wasser, 1982; Watson, et al., 1980). Growth begins in the spring, with maturity in the summer. Foliage has high protein content (Hafenrichter, et al., 1968) and good palatability to livestock and wildlife when green (Shaw and Cooper, 1973).

Ecological Setting: Mountain brome is adapted to medium- and fine-textured soils that are moderately deep (Heady, 1975; Vallentine, 1971; Wasser, 1982). It is tolerant of weakly acidic to moderately alkaline soils and tolerates salt concentrations of 4 to 8 mmhos/cm (Watson, et al., 1980). This species generally occurs in MAP zones that exceed 46 cm (Thornberg, 1982). Mountain brome has low to moderate drought tolerance

and good tolerance for grazing, cold, and shade (Wasser, 1982; Watson, et al., 1980). This species is moderately aggressive on mesic sites.

Uses: Mountain brome is suitable for soil stabilization and as a forage species. This species may be useful in portions of Forts Carson, Riley, and Sill.

Establishment: Seeds should be planted 1.3 to 2.5 cm deep at rates of 9 to 13 kg PLS/ha (Wasser, 1982; Watson, et al., 1980). Mulching and fertilization will improve establishment and stand development. Seeds should be treated with fungicide to reduce head smut (Hafenrichter, et al., 1968). Germination is 85 percent (Hafenrichter, et al., 1968), with most seeds germinating in 14 days (Wasser, 1982). Vigor and growth are rated as moderate and good, respectively, and stands can develop in 2 years. Seeds can be stored for 3 years (Hafenrichter, et al., 1968), and there are 140,000 (AOSA, 1978) to 198,000 seeds/kg (Heady, 1975).

Availability/Cultivars: Seeds are readily available; Bromar is a released cultivar.

27. Orchardgrass (Dactylis glomerata)

Distribution: This species ranges from Florida to central California, northward to Canada (Wasser, 1982).

Description: Orchardgrass is an introduced, cool-season, C-3, long-lived, perennial bunchgrass (Thornberg, 1982). It grows to be 60 to 120 cm tall and has a moderately extensive, fibrous root system (Thornberg, 1982; Wasser, 1982). Its foliage, both during growth and after maturity, is highly palatable to livestock and wildlife, providing good nutritional value. Its seeds are eaten by songbirds.

Ecological Setting: Orchardgrass is adapted to coarse- and medium-textured soils that are fertile and well-drained (Thornberg, 1982; Wasser, 1982). It is adapted to slightly alkaline to moderately acid pHs and tolerates salinity levels of 4 to 8 mmhos/cm (Watson, et al., 1980). This species is found in MAP zones of more than 30 cm (Hafenrichter, et al., 1968). It has low to moderate drought tolerance, although this tolerance is better than that of timothy or Kentucky bluegrass. Orchardgrass is highly tolerant of grazing and shade but, is susceptible to cold temperatures (Watson, et al., 1980). This species is moderately competitive.

Uses: Orchardgrass is an excellent forage species and is a good soil builder and stabilizer. It may be useful at Forts Carson, Hood, Riley, and Sill.

Establishment: A seed mixture with 2.2 kg PLS/ha mixed with legumes (Echols, and Cuany, 1974; Hafenrichter, et al., 1968) and planted 2.5 cm deep is recommended (Rogler, et al., 1961). High germination (80 to 98 percent) (Fulbright, et al., 1982), good vigor, and moderate growth make this plant suitable for establishment on submesic areas (Watson, et al., 1980). Seeds retain good viability for several years. There are 840,000 to 1,190,000 seeds/kg (AOSA, 1978; Heady, 1975), and seeds can be stored for more than 10 years (Fulbright, et al., 1982).

Availability/Cultivars: Many cultivars that are adapted to Colorado are available, including Sterling, Pomar, and Latar. Seeds are also commercially available.

28. Prairie sandreed (Calamovifa longifolia)

Distribution: This species is found from eastern Colorado and western Kansas, northward to Canada, and from Montana to the Great Lakes states (Hitchcock, 1950).

Description: Prairie sandreed is a native, warm-season, C-4, sod-forming grass. Culms are 50 to 180 cm tall (Hitchcock, 1950). Growth begins in late spring, with good regrowth in late summer (Wasser, 1982). Foliage is moderately palatable to livestock in summer and winter. It is of poor forage value for mule deer and game birds, but of fair value for small mammals.

Ecological Setting: This species is best adapted to coarse-textured and sandy soils (Harrington, 1979), but it also grows well on silty soils (Watson, et al., 1980). It occurs in MAP zones of 25 to 50 cm (Thornberg, 1982). It is not tolerant of salt or acid, but does tolerate weakly alkaline sites. It is tolerant of cold, light to moderate grazing, and drought, and intolerant of flooding, shade, and trampling (Wasser, 1982; Watson, et al., 1980). It is tolerant of fire when dormant, and is competitive when well-established.

Uses: The primary use of prairie sandreed is for erosion control. This species is adapted to Forts Carson and Sill and may be useful at Forts Hood and Riley.

Establishment: Drill-seeding 1.3 to 2.5 cm deep on medium- and coarse-textured soils, respectively, at rates of 4.5 to 8 kg PLS/ha is recommended (Fulbright, et al., 1982; Wasser, 1982). Seeds germinate in 1 month after pre-chilling; germination capacity is 75 percent (Stefferud, 1948). Seedling vigor is fair; stands may require 3 years to become fully established (Wasser, 1982). Mulching and irrigation will improve establishment. There are 602,800 seeds/kg (Vallentine, 1971).

Availability/Cultivars: Goshen is a cultivar adapted to Wyoming, Montana, Nebraska, and the Dakotas. Seeds are commercially available.

29. Pubescent wheatgrass (Agropyron trichophorum)

Distribution: This species is found throughout the northwest United States from the northern Great Plains to Oregon and Washington, and south to Colorado, Utah, and northern portions of New Mexico and Arizona (Hitchcock, 1950).

Description: Pubescent wheatgrass is an introduced, cool-season, long-lived, rhizomatous perennial grass (Hafenrichter, et al., 1968; Watson, et al., 1980). Growth begins in early spring, but occurs later than the growth of desert wheatgrass. It goes dormant under drought conditions and attains a height of 75 to 110 cm. This species is a highly nutritious

forage that is moderately to highly palatable to livestock and wildlife (Watson, et al., 1980).

Ecological Setting: Pubescent wheatgrass is adapted to sandy to clayey soil textures (Vallentine, 1971) that are weakly acidic to moderately alkaline (Hafenrichter, et al., 1968). It is moderately saline-tolerant (USDA-SCS, 1976) and is found in MAP zones of 25 to 50 cm (Thornberg, 1982). This species is highly tolerant of drought and grazing, moderately cold-tolerant, and has low shade tolerance (Watson, et al., 1980). It is also an aggressive competitor.

Uses: Pubescent wheatgrass is a good forage plant and soil stabilizer for extensive, long-term erosion control. It is adapted for use at Forts Carson, Riley, and Sill.

Establishment: Pubescent wheatgrass is similar to other introduced wheatgrasses in establishment requirements. Seeds should be planted 1.3 to 2.5 cm deep (McGinnies, 1960) at 13 kg PLS/ha (Echols and Cuany, 1974). Seed germination capacity is 85 to 90 percent (Fulbright, et al., 1982), occurring in 7 to 28 days. The species has excellent seedling vigor and good growth (Hafenrichter, et al., 1968), and stands can fully establish in two or three growing seasons. There are 165,000 to 190,600 seeds/kg (AOSA, 1970).

Availability/Cultivars: Several cultivars that can be used in MAP zones of less than 15 cm (Watson, et al., 1980) are available, including Greenleaf, Topar, Lunar, and Trigo. Greenleaf is saline-tolerant.

30. Redtop (Agrostis alba)

Distribution: This species is found in every state of the continental United States (Wasser, 1982).

Description: Redtop is an introduced, cool-season, C-3, perennial sod-former. Culms are 30 to 120 cm tall (Hitchcock, 1950; Wasser, 1982) and plants are shallowly rooted (Watson, et al., 1980). Growth begins in the spring, with plants becoming dormant in midsummer, and regrowth occurring in the fall on mesic sites. Foliage is highly palatable to livestock and wildlife in the spring and early summer, but not in the winter. It is relatively aggressive in moist areas and colonizes disturbed sites (Watson, et al., 1980).

Ecological Setting: Redtop is adapted to all soil textures but does best on loamy soils (Wasser, 1982). It occurs on mesic, poorly drained sites, and is tolerant of moderately acidic (to pH 4.5) and slightly saline soils. It does not occur on soils developed in limestone. This species has good tolerance of grazing and cold, and is moderately tolerant of fire and drought (Watson, et al., 1980). It does best in MAP zones that exceed 50 cm (Wasser, 1982).

Uses: The most appropriate use for this species is long-term erosion control on mesic and flood-prone sites. Redtop is suited for testing on mesic sites at Forts Carson, Riley, and Sill.

Establishment: Drill seeding at depths of 1.3 cm or less is best, at rates of 1.1 (Echols and Cuany, 1974) to 5.5 kg PLS/ha (Wasser, 1982). Seeds germinate rapidly, and seedling vigor is good under good growing conditions. Stands develop in one or two growing seasons. This species is susceptible to leaf rusts, spotting, and snow mold. There are 11,000 seeds/kg, and stored seeds are viable for at least 6 years (Wheeler and Hill, 1957).

Availability/Cultivars: There are no improved cultivars; however, seeds are commercially available.

31. Reed canarygrass (Phalaris arundinacea)

Distribution: This species ranges from the Atlantic coast to northern portions of New Mexico and Arizona, Nevada, and northern California (Wasser, 1982). It is also found in portions of the eastern United States and Canada.

Description: Reed canarygrass is a native, C-3, cool-season, perennial grass that is long-lived (Thornberg, 1982). It is rhizomatous and reaches a height of 60 to 180 cm (Wasser, 1982). Growth begins in early spring and continues until the first killing frost. Foliage is moderately palatable to livestock and wildlife during the growing season, and seeds are eaten by many wildlife species.

Ecological Setting: Reed canarygrass is adapted to soils with sandy to clayey textures but prefers finer-textured soils (Vallentine, 1971) that are poorly drained (Thornberg, 1982). It has a wide pH tolerance and is moderately saline-tolerant. This species is found in MAP zones that exceed 43 cm (Thornberg, 1982). It is moderately tolerant of drought, cold, flood, and fire, has good grazing tolerance, and has low shade tolerance. It has better cold tolerance under moist conditions.

Uses: Reed canarygrass provides good wildlife cover and soil stabilization on semihydric soils. It is frequently used on levees and dikes in seed mixtures in the north central United States. This species is adapted for use at Forts Carson, Riley, and Sill.

Establishment: Seeds should be planted 0.6 to 2.0 cm deep at rates of about 4.5 kg PLS/ha (Echols and Cuany, 1974) to establish pure stands (Wasser, 1982). Germination capacity is commonly 80 to 90 percent (Fulbright, et al., 1982). Control of weeds and grazing animals is important during the first growing season. Recently harvested seeds should be used because viability declines rapidly with storage. Seedling vigor is moderate; stands may require 3 years to become fully established, although plants can grow 25 to 50 cm in the first growing season (Wasser, 1982). There are 1,185,000 to 1,213,000 seeds/kg (AOSA, 1978). Seeds should not be stored longer than 5 years (Hafenrichter, et al., 1968).

Availability/Cultivars: There are several available cultivars, including Castor, Suba, and Frontier.

32. Russian wildrye (Elymus junceus)

Distribution: This species occurs from Minnesota to western Washington, and southward to Arizona and New Mexico.

Description: Russian wildrye is an introduced, C-3, cool-season, perennial bunchgrass. It has a deep, fibrous root system and attains a maximum height of 90 to 120 cm (Watson, et al., 1980). Growth begins in early spring, and plants mature in mid to late summer. Foliage is highly palatable to livestock and wildlife, and is highly nutritious during the growing season (Plummer, et al., 1968; Watson, et al., 1980).

Ecological Setting: This wildrye species is best adapted to moderately deep, basic, coarse-textured soils (Vallentine, 1971). It can grow in saline soils with electrical conductivities as high as 11 to 16 mmhos/cm (Watson, et al., 1980). The species occurs in 25- to 40-cm MAP zones (Lang, et al., 1975) and is drought-hardy (Jordan, 1981). It is tolerant of grazing and trampling, but has poor shade tolerance; once established, it is competitive.

Uses: Russian wildrye is a good species for renovating disturbed greasewood and saltgrass areas for dryland pasture use. It is adapted for use at Forts Carson, Riley, and Sill, and may be useful at Fort Bliss in the installation's more mesic areas.

Establishment: Seed-drilling at a rate of 5.5 kg PLS/ha (Vallentine, 1971) 1.3 to 2.5 cm deep (McGinnies, 1974), is recommended. Fertilization and irrigation will aid plant establishment. Stands should be protected for two growing seasons to allow enough time for roots to develop fully. Between 80 and 90 percent of seeds germinate under laboratory conditions (Fulbright, et al., 1982); however, seedling vigor is weak. Seeds can be stored for 5 years (McWilliams, 1950), and there are about 385,000 seeds/kg (Vallentine, 1971).

Availablity/Cultivars: Several varieties of cultivars are commercially available, including Vinal, Mayak, Piper, Swift, Cabree, and Sawki.

33. Sandberg bluegrass (Poa secunda)

Distribution: This species ranges from North Dakota and western Washington to New Mexico and California (Harrington, 1979; Hitchcock, 1950).

Description: Sandberg bluegrass is a native, C-3, cool-season, perennial bunchgrass. It has a shallow to deep fibrous root system and grows 20 to 40 cm high (Cronquist, et al., 1977). Growth begins in early spring, and plants mature in early summer. Fall regrowth occurs when moisture is sufficient (Wasser, 1982). When green, foliage has excellent palatability for livestock and wildlife (Plummer, et al., 1968; Vallentine, 1967); however, palatability is poor when the grass is dormant (Plummer, et al., 1968).

Ecological Setting: Sandberg bluegrass is adapted to sandy to clayey soils that are shallow and rocky (Wasser, 1982). The species grows best on clay loams (USDA--Forest Service, 1937). It has a narrow pH range and is

weakly saline-tolerant (Wasser, 1982). This bluegrass is generally found in 25- to 50-cm MAP zones, but is also reported in 18- to 25-cm MAP zones (Thornberg, 1982). It is moderately tolerant of fire, grazing, cold, shade, and drought (Plummer, et al., 1968; Wasser, 1982). It is not overly aggressive, but is compatible with other species (Wasser, 1982).

Uses: Sandberg bluegrass has potential as an early-season forage plant and soil stabilizer for shallow soils. It could be tested at Fort Carson.

Establishment: Planting at rates of 180 to 360 PLS/m^2, 0.6 to 1.2 cm deep is generally recommended for establishing pure stands (Wasser, 1982). Seed germination is good (81 percent in 28 days) (McDonough, 1970); however, vigor is poor, growth is moderate (Plummer, et al., 1968), and stands will probably require two or more growing seasons to fully establish under optimum conditions. There are 1,980,000 to 2,025,000 seeds/kg (Hafenrichter, et al., 1968; Wheeler and Hill, 1957).

Availability/Cultivars: There are no improved varieties available.

34. Sand dropseed (Sporobolus cryptandrus)

Distribution: This species is found throughout the United States except in the southeast (Hitchcock, 1950).

Description: Sand dropseed is a native, C-4, warm-season, perennial bunchgrass. It has a fibrous root system and grows 20 to 100 cm tall (Harrington, 1979). Growth begins in spring or early summer (Jordan, 1981) with plants maturing in late summer. Foliage is moderately palatable to livestock (Vallentine, 1971); this species is an important winter forage grass, because it maintains fair nutritive qualities at this time (Thornberg, 1982).

Ecological Setting: Sand dropseed usually occurs on sands and silts (Thornberg, 1982) but it can also grow on clayey soils (Thornberg, 1982). It is tolerant of moderately alkaline soils. It is moderately saline-tolerant (Valentine, 1971). Sand dropseed is found in MAP zones of 20 to 50 cm (Thornberg, 1982). This species is tolerant of drought, grazing, and cold (Vallentine, 1971), but is intolerant of shade (Jordan, 1981; Plummer, et al., 1968). Established plants are moderately competitive.

Uses: Sand dropseed is recommended for sandy soil stabilization and for lengthening the winter grazing season. It is adapted for use at Forts Bliss, Carson, and Sill, and could be tested at Forts Irwin and Riley.

Establishment: Planting seeds 0.6 to 1.2 cm deep (Allred and Nixon, 1955) at rates of 2 to 3.5 kg PLS/ha is recommended to establish stands. Seed germination is about 80 percent (Stefferud, 1948); however, germination, vigor, and growth rates are slow (Jordan, 1981). Pre-chilling seeds for 4 to 8 weeks has been recommended before planting (Fulbright, et al., 1982). Stored seed viability ranges between 1 and 5 years, (Archer and Bunch, 1953), and there are 12,345,000 seeds/kg (AOSA, 1978).

Availability/Cultivars: No cultivars are available, although seeds are commercially available.

35. Sand lovegrass (Eragrostis trichodes)

Distribution: This species is found from Nebraska and Iowa south to Texas, as well as in Illinois and Colorado (Hitchcock, 1950).

Description: Sand lovegrass is a warm-season, C-4, perennial, native bunchgrass. It has a fibrous root system and attains a height of 60 to 120 cm. Growth begins in late spring, and plants mature in the fall. Foliage is moderately palatable to livestock due to its high protein content, which is high in the spring and moderate in the summer.

Ecological Setting: This species grows best in sandy soils but is also found on silty soils (Thornberg, 1982). It occurs on calcareous sites in MAP zones of 23 to 50 cm. It is tolerant of drought and cold and moderately tolerant of grazing, but has poor salt tolerance (Vallentine, 1971).

Uses: This species is excellent for sandy soil stabilization and for forage production. It is adapted for use at Forts Bliss, Carson, Riley, and Sill.

Establishment: Sand lovegrass should be seeded 0.6 to 1.3 cm deep at 0.6 to 1.1 kg/ha on a firm smooth seedbed. Germination, seedling vigor, and growth are good. Stands will require 2 years of protection to fully develop. There are 2,860,000 seeds/kg (Vallentine, 1971).

Availability/Cultivars: Cultivars include Bend, Mason, and Nebraska 27; seeds are also available.

36. Sideoats grama (Bouteloua curtipendula)

Distribution: This species ranges from southern California through Texas and northward through the Intermountain, Rocky Mountain, and Great Plain regions to the Atlantic Coast (Hitchcock, 1950).

Description: Sideoats grama is a native, warm-season, C-4, perennial sodformer. Culms are 25 to 80 cm tall and leaves form dense tufts (Harrington, 1979). Growth begins in midspring, with plants maturing in the summer through fall (Vallentine, 1967). Foliage is highly palatable to livestock, wildlife, and small mammals in the spring and summer, and the seeds are eaten by song and game birds.

Ecological Setting: This species is adapted to sandy to clayey soils, and is weakly to moderately salt-tolerant (Thornberg, 1982). It occurs in MAP zones of 20 to 50 cm (Thornberg, 1982). Sideoats grama is cold-hardy and is moderately tolerant of flooding, shade, grazing, and drought (Wasser, 1982). It has low fire tolerance.

Uses: Sideoats grama provides long-term erosion control and forage for livestock. It is adapted for use at Forts Bliss, Carson, Hood, Riley, and Sill.

Establishment: Sideoats grama should be drill-seeded 0.6 to 2.0 cm deep on fine- and coarse-textured soils, respectively, at 4.0 to 6.0 kg PLS/ha (Allred and Nixon, 1955; Wasser, 1982). Mulching and light irrigation will ensure stand establishment. Pitting, furrowing, and water catchment basins may be required on more arid lands to ensure stand establishment. Seeds germinate in 7 to 28 days, and seedling vigor is fair to good (Wasser, 1982). Germination capacity is 60 to 85 percent (Wheeler and Hill, 1957). Under optimum conditions, a good stand can be established by the end of the first growing season. There are 220,000 to 315,000 seeds/kg (Fulbright, et al., 1982), and viability is still maintained after 8 years of storage (McWilliams, 1950).

Availability/Cultivars: El Reno is an appropriate cultivar for Kansas and Oklahoma, and Pierre is adapted to South Dakota. Butte and Trailway are adapted to western and eastern Nebraska, respectively. Uvalde is adapted to central and south Texas, and Premier to north Texas (Thornberg, 1982). Coronado is adapted to the Texas panhandle, Tucson to west Texas, southern New Mexico, and Arizona, and Vaughn to eastern New Mexico and southeast Colorado.

37. Slender wheatgrass (Agropyron trachycaulum)

Distribution: This species occurs in the northern United States, from Maine and West Virginia to California and northern portions of Arizona and New Mexico (Hitchcock, 1950).

Description: Slender wheatgrass is a native, short-lived, perennial, cool-season bunchgrass. It has a fibrous root system and grows 50 to 100 cm tall. The species also has short rhizomes (Watson, et al., 1980). Growth begins in the spring, with plants maturing in the late summer. Its foliage is nutritious during the growing season and is palatable to wildlife, small mammals, and livestock.

Ecological Setting: Slender wheatgrass is found on sandy loam to clayey soils (Fulbright, et al., 1982), and grows on both moist and dry sites. It is highly tolerant of alkaline soils to pH 9.0 (Wasser, 1982). Generally found in MAP zones of 25 to 36 cm, it is moderately drought-tolerant but less so than other wheatgrasses. It is moderately tolerant of grazing, cold, and shade, and is also moderately competitive.

Uses: This species is good for short-term erosion control, provides forage, and has been used in seeding occasionally flooded, upper-reservoir banks in the west. It is adapted for use at Forts Carson, Riley, and Sill.

Establishment: Like other wheatgrass species, it is seeded 1.3 to 2.5 cm deep (Stefferud, 1948) at 4.5 to 9 kg PLS/ha for pure stands. Seeds germinate in 7 to 28 days and have an 80 to 90 percent germination capacity. Vigor and growth are generally rated as good, and stands can develop in two or three growing seasons. Fertilization and irrigation can improve establishment. There are 275,000 to 295,000 seeds/kg (Fulbright, et al., 1982), and the seeds remain viable for 6 years (Hafenrichter et al., 1968).

Availability/Cultivars: Seeds are readily available commercially, and some cultivars are also available, including Revenue and Primar.

38. Smooth brome (Bromus inermis)

Distribution: This species is found from northern regions of California, Arizona, New Mexico, Texas, and Oklahoma, northward into Canada (Wasser 1982).

Description: Smooth brome is an introduced, cool-season, C-3, long-lived, perennial sod-former. Northern types are weakly rhizomatous, and southern types are strongly rhizomatous (Watson, et al., 1980). Culms are 40 to 100 cm tall (Harrington, 1979; Hitchcock 1950). Growth begins in early spring (Hafenrichter, et al., 1968), with plants maturing in July (Wasser, 1982). Regrowth will occur in the fall as cool temperatures and rain stimulate growth. When young and green, foliage is highly palatable to livestock and geese, and is is moderately palatable to deer.

Ecological Setting: This grass is best adapted to deep, fertile, well-drained clayey and silty soils (Thornberg, 1982) and requires a minimum of 28 to 38 cm of precipitation annually to grow vigorously (Hafenrichter, et al., 1968). Smooth brome is also found on sandy soils (Watson, et al., 1980). It is moderately tolerant of saline, alkaline, and acid soils (Wasser, 1982; Watson, et al., 1980). It has good tolerance for cold temperatures and shade, and moderate tolerance for drought, fire, and temporary flooding (Wasser, 1982; Watson, et al., 1980). This species is not suitable to southern climates below 1500 m. On mesic sites, it is competitive and highly aggressive when fertility levels are high.

Uses: Smooth brome provides good long-term erosion control and early forage production. It is adapted for use at Fort Riley and may be useful in mesic areas at Forts Carson and Sill.

Establishment: Smooth brome should be seeded at 5.5 to 8 kg PLS/ha, about 1.3 to 2.5 cm deep (Wasser, 1982). Prechilled seeds germinate in 14 days (Wasser, 1982), and its germination capacity is 80 to 90 percent (Wheeler and Hill, 1957); seedling vigor is excellent (Watson, et al., 1980). Stands require two growing seasons for good establishment. Irrigation and fertilization increase forage production, but continued fertilization may be required to maintain vigorous stands. There are about 300,000 seeds/kg, and seeds retain good viability for 4 to 14 years in storage (Fulbright, et al., 1982).

Availability/Cultivars: Seeds are available throughout the geographical range of this species. Many cultivars exist, including Southland and Achenbach, which are adapted to Oklahoma and Kansas, respectively. The cultivar Manchar has been used in the Rocky Mountain region.

39. Spike muhly (Muhlenbergia wrightii)

Distribution: This species occurs in Colorado, Utah, New Mexico, and Arizona (Harrington, 1979; Hitchcock, 1950).

Description: Spike muhly is a native, warm-season, C-4, perennial bunchgrass. Culms grow to be 20 to 60 cm high, and plants have a well-developed, fibrous root system (Thornberg, 1982). Some plants are reported to have short stolons (New Mexico State University, Cooperative Extension Service, 1978). Foliage of this species is highly palatable to both livestock and wildlife (Thornberg, 1982), and birds eat its seeds.

Ecological Setting: Spike muhly is adapted to all soil textures, but does best on sands, loams, and silts (USDA Forest Service, 1937; Thornberg, 1982). It occurs in pinyon-juniper and ponderosa pine vegetation zones in meadow openings (New Mexico State University, Cooperative Extension Service, 1978). This species is adapted to MAP zones of 25 to 45 cm (Jordan, 1981; Thornberg, 1982). It is probably tolerant of grazing, fire, and cold.

Uses: This species is an excellent soil binder and a good selection for stabilizing disturbed sites. It is adapted for use at Fort Bliss and could be tested at Fort Carson.

Establishment: Seeds should be planted 0.6 cm deep at rates of 2.2 to 3.3 kg PLS/ha (New Mexico State University, Cooperative Extension Service, 1978). It is recommended that 90 kg/ha of nitrogen be used for stand establishment. Irrigation will also improve stand establishment.

Availability/Cultvars: The cultivar El Vado is a recent release; seeds are limited.

40. Streambank wheatgrass (Agropyron riparium)

Distribution: Streambank wheatgrass occurs in western states from North Dakota to Washington and Oregon, and southward to Colorado and Nevada (Hitchcock, 1950).

Description: This species is a native, cool-season, long-lived, perennial rhizomatous grass (Hitchcock, 1950). Plant growth begins in the spring; plants mature in late summer and reach a height of 65 cm. Its foliage is less palatable than that of other wheatgrass species to livestock, wildlife, and small mammals, but it is moderately nutritious (Wasser, 1982).

Ecological Setting: Streambank wheatgrass occurs on coarse- to fine-textured soils (USDA--Forest Service, 1966) that are well-drained and vary in pH from moderately alkaline to slightly acid (Watson, et al., 1980). It is tolerant of drought, moderately tolerant of salinity, and occurs in MAP zones of 13 to 23 cm (Thornberg, 1982). However, 30 cm is its minimum MAP zone at elevations lower than 1000 m. It is tolerant of cold and grazing, is highly competitive, and probably tolerant of fire due to its rhizomatous nature.

Uses: This wheatgrass has been used for soil stabilization in dry areas and for stream channel revegetation projects. Streambank wheatgrass is suitable for testing at Forts Bliss, Carson, Riley, and Sill.

Establishment: As with the other wheatgrasses, the practice of drill-seeding 1.3 to 2.5 cm deep at 7 to 8 kg PLS/ha is generally recommended (Echols and Cuany, 1974; Wasser, 1982). Fertilization and irrigation will allow stands to develop in 2 or 3 years. Germination capacity is 95 percent (Wheeler and Hill, 1957) and requires 7 to 28 days. Both seedling vigor and growth rate are good. There are 343,200 seeds/kg (Wheeler and Hill, 1957), and stored seeds remain viable for several years.

Availability/Cultivars: Seeds are widely available; Sodar is a released cultivar that is commonly used.

41. Switchgrass (Panicum virgatum)

Distribution: This species occurs from central Nevada, Arizona, southern Utah, eastern Montana, and eastern Wyoming, eastward to the Atlantic coast of the United States (Hitchcock, 1950; Wasser, 1982).

Description: Switchgrass is a native, warm-season, C-4, perennial, sodforming grass. Culms are generally 60 to 200 cm tall (Hitchcock, 1950). Growth begins in the late spring, with plants maturing in late summer to early fall (Wasser, 1982). Its foliage is highly palatable to livestock in the growing season, but not during the fall and winter. Its seeds are eaten by many species of birds.

Ecological Setting: This grass is adapted to all soil textures in mesic areas (Wasser, 1982), but grows best on fertile, subirrigated silty to clayey soils (Thornberg, 1982). It requires a minimum MAP of 41 cm (Thornberg, 1982; Wasser, 1982). It is moderately tolerant of saline and acid (4.0 to 4.5 pH) and tolerates temporary spring flooding. It is winter-hardy and moderately tolerant of burning and grazing.

Uses: This species provides long-term erosion control and forage for livestock, as well as cover and food for selected wildlife species (Thornberg, 1982). It is used for soil stabilization on reservoir banks in middle to upper zones. Switchgrass is adapted for use in mesic areas at Forts Carson, Hood, Riley, and Sill.

Establishment: Seeds should be drilled 0.6 to 2.0 cm deep at rates of 2.2 to 3.5 kg PLS/ha (Wasser, 1982). Prechilled seeds have 50 to 60 percent germination in 7 to 28 days under laboratory conditions. Use of year-old seeds is preferred. Seedling vigor is only fair (Fulbright, et al., 1982; Wasser, 1982), with stands requiring 2 or 3 years to develop fully. Reduction of weedy competition during seeding and establishment is important. Use of fertilizer will aid stand development. There are 485,000 to 655,000 seeds/kg (AOSA, 1978), and seed viability is good after 3 years of storage (Wolff, 1951).

Availability/Cultivars: Several cultivars are available: Alamo for Texas, Blackwell and Caddo for Oklahoma, Kanlow for Kansas, Oklahoma, and Texas, Granville for New Mexico, and Nebraska 28, Pathfinder, and Summer for Nebraska and South Dakota.

42. Tall fescue (Festuca arundinacea)

Distribution: This species generally occurs throughout the United States (Wasser, 1982).

Description: Tall fescue is an introduced, cool-season, C-3, rhizomatous bunchgrass. Culms are 50 to 120 cm tall (Hitchcock, 1950). Growth begins in spring, plants mature in summer, and regrowth can occur in summer and fall (Schuster and deLeon Garcia, 1973; Wasser, 1982). This species grows primarily during the winter in extreme southern latitudes. Its foliage is moderately palatable to livestock, and has moderate to low palatability to wildlife. Its seeds are eaten by song and game birds.

Ecological Setting: Tall fescue is adapted to a wide range of textures, but is best suited to deep, fertile silty and clayey soils (Wasser, 1982; Watson, et al., 1980). It grows in a wide range of soil pHs (3.6 to 8.0) (Wasser, et al., 1980). This species tolerates poor drainage, temporary flooding, and slightly to highly (8 to 12 mmhos/cm) saline soils (USDA--SCS, 1971). It grows in MAP zones that exceed 45 cm (Thornberg, 1982). It is tolerant of grazing and cold and moderately tolerant of shade and short-term droughts (Wasser, 1982; Watson, et al., 1980), but it cannot withstand long-term droughts. Tall fescue is very competitive on fertile sites with sufficient rainfall (Moyer and Seamands, 1975).

Uses: This species is useful as a perennial hay or pasture crop and for erosion control (Thornberg, 1982). It can also be used as a nurse crop. It is frequently planted on levees, dikes, and highway rights-of-way as a soil stabilizer. Tall fescue is adapted for use in appropriate areas at Forts Carson, Riley, and Sill and could be tested at Fort Hood.

Establishment: Tall fescue should be seeded at rates of 2 to 20 kg PLS/ha at 0.6 to 2.5 cm deep (Wasser, 1982). Prechilled seeds germinate in 14 days under laboratory conditions. Germination capacity is 80 to 90 percent (Fulbright, et al., 1982), and seedling vigor is fair. Stands may require 2 years to fully establish (Wasser, 1982). This species is best seeded alone or with a robust legume because of its highly competitive nature and high nitrogen requirements. There are 390,000 to 534,000 seeds/kg (Heady, 1975), and seeds are viable up to 10 years (Hafenrichter, et al., 1968).

Availability/Cultivars: This species is readily available, and several cultivars that are adapted to various western states have been released, including Alta, Goar, and Fawn.

43. Tall wheatgrass (Agropyron elongatum)

Distribution: This wheatgrass ranges from Idaho and the Dakotas south to northwest Kansas, northwest Arizona, and northeast New Mexico (Wasser, 1982).

Description: Tall wheatgrass is an introduced, C-3, cool-season, perennial bunchgrass. It has a deep root system (Thornberg, 1982), and can reach a height of 150 cm if irrigated (Wasser, 1982); however, heights of 90 cm are more common. Growth begins in April, with plants maturing in

September (Wasser, 1982). Foliage is rated poor to moderate in its palatability to livestock and wildlife.

Ecological Setting: Tall wheatgrass is adapted to silty and clayey soils whose pHs range from 4.7 to 9.5 (Moyer and Seamands, 1975). It is salt-tolerant to 10 mmhos/cm (Bernstein, 1964), and is found in MAP zones of 13 to 23 cm (Lang, et al., 1975). It shows good tolerance for fire and cold, moderate tolerance for shade and drought, and poor tolerance for grazing (Hafenrichter, et al., 1968).

Use: This species is an excellent selection for soil stabilization on saline and alkaline sites. Tall wheatgrass may be useful at Forts Carson, Riley, and Sill.

Establishment: Wasser (1982) recommends 6.5 to 17.0 kg PLS/ha planted 1.2 to 2.0 cm deep for fine-textured soils and 2.5 to 3.7 cm deep for coarse-textured soils. The higher seeding rates are appropriate for irrigated pasture establishment. Seed germination is about 90 percent (Fulbright, et al., 1982), with most seeds germinating in 21 days (Wasser, 1982). Seedling vigor is fair, and stands become fully developed in two or three growing seasons.

Availability/Cultivars: Several cultivars are commercially available, including Alkar for Washington, Jose and Largo for New Mexico, and Platte for Nebraska.

44. Thickspike wheatgrass (Agropyron dasystachyum)

Distribution: This species ranges throughout the northern half of the western United States as well as through northern New Mexico and Arizona (Harrington, 1979; Hitchcock, 1950).

Description: Thickspike wheatgrass is a native, cool-season, C-3, perennial grass (Thornberg, 1982). It has a moderately deep, rhizomatous root system. It begins growing in the spring, matures in July and August, and grows to be 90 cm high (Harrington, 1979). Its foliage is palatable to elk, small mammals, and livestock year-round, although its palatability to livestock declines in the winter (Wasser, 1982). It is also moderately palatable to deer in the spring.

Ecological Setting: Thickspike wheatgrass is adapted to sandy (Harrington, 1979) to clayey (Wasser, 1982) soil textures and to well-drained sites (Hull and Johnson, 1955). It can tolerate temporary flooding and slightly saline soils, but requires good fertility (Wasser, 1982). Thickspike wheatgrass occurs in MAP zones of 14 to 50 cm (Lang, et al., 1975). It is tolerant of fire and drought, moderately tolerant of shade and grazing, and competitive with other species.

Uses: This species is a good selection for long-term, extensive soil stabilization, and is moderately useful as a forage crop. It is adapted for use at Fort Carson and may be suitable for testing at Forts Riley and Sill.

Establishment: Drill-seeding 1.3 to 2.5 cm deep at 5.5 to 7.5 kg PLS/ha is generally recommended to establish pure stands (Echols and Cuany, 1974;

Wasser, 1982). Reduction of competition is important, and fertilization may be required to maintain stands. Seeds germinate in 21 days under lab conditions (Wasser, 1982), with 85 percent having the potential to germinate (Wheeler and Hill, 1957). Its seedlings are more vigorous than western wheatgrass but less than for introduced wheatgrasses. Stands may require 2 or 3 years to become fully established. There are 338,800 seeds/kg (Wheeler and Hill, 1957).

Availability/Cultivars: The cultivar Critana has been used successfully for seeding disturbed areas with less than 46 cm MAP; seeds are readily available (Thornberg, 1982).

45. Timothy (Phleum pratense)

Description: This species occurs throughout the United States except for southern portions of California, Arizona, and New Mexico and west Texas (Hitchcock 1950; Wasser, 1982).

Description: Timothy is an introduced, cool-season, C-3, short-lived, perennial bunchgrass (Watson, et al., 1980). It has a shallow, fibrous root system and grows 50 to 100 cm tall (Hitchcock, 1950). Growth begins in the spring, with plants reaching maturity in late summer. Some fall regrowth occurs if fall precipitation is sufficient. Foliage is palatable and nutritious to livestock and wildlife during the growing season (Wasser, 1982; Watson, et al., 1980). Canada geese frequently graze timothy stands, and some waterfowl species use it for nesting cover.

Ecological Setting: This species occurs on soils with a wide variety of soil textures, but does best on moderately deep loams with moderate fertility (Vories and Sims, 1977). It is tolerant of acidic soils having pHs as low as 4.5 (Rafaill and Vogel, 1978; Wasser, 1982). Timothy is adapted to MAP zones that exceed 38 cm (Lang, et al., 1975). It has poor tolerance for drought and grazing, moderate tolerance for fire, and good tolerance for cold and shade (Wasser, 1982; Watson, et al., 1980). This species is moderately competitive.

Uses: Timothy is an excellent forage crop and is a good erosion control plant in mesic environments. It is adapted for use at Forts Carson, Hood, Riley, and Sill.

Establishment: Drill-seeding 0.6 to 2.0 cm deep at rates of 2.0 to 2.5 kg PLS/ha has been recommended (Archer and Bunch, 1953; Wasser, 1982). Germination capacity is 90 to 100 percent, with seeds germinating in 7 days (Gordon, 1951). Seedling vigor is moderate, and stands mature in one or two growing seasons (Wasser, 1982). Mulching, fertilization, and irrigation help establish stands, but hydromulching should not be used. Seeds remain viable for 1 to 10 years in storage (Fulbright, et al., 1982). There are 2,405,000 to 2,865,000 seeds/kg (AOSA, 1978; Heady, 1975).

Availability/Cultivars: There have been 25 cultivars released in the United States, and seeds are readily available.

46. Weeping lovegrass (Eragrostis curvula)

Distribution: This species occurs throughout the southern half of the United States except in California. It usually grows south of a line from Kansas to southern Pennsylvania (Hitchcock, 1950).

Description: Weeping lovegrass is an introduced, warm-season, C-4, perennial bunchgrass (Thornberg, 1982). Culms grow 60 to 120 cm tall (Hitchcock, 1950). Growth begins in early spring, with plants maturing in midsummer. It is a robust plant with rapid growth that requires intensive management and grazing pressure to maintain palatability for livestock. The species has very little wildlife value.

Ecological Setting: This grass is best suited to fertile silty and sandy soils and is adapted to MAP zones of 30 to 100 cm (Thornberg, 1982). The species is highly tolerant of alkaline and acidic soils. It is tolerant of burning and grazing, moderately tolerant of shade, and sensitive to cold.

Uses: Under intensive management, this species provides long-term erosion control and high forage production. It is considered a pest species in southeastern pastures. Weeping lovegrass is adapted for use at Forts Bliss, Hood, and Sill, and could be tested at Fort Irwin.

Establishment: Weeping lovegrass should be seeded at 1 to 3 kg PLS/ha about 0.6 to 1.3 cm deep. Seeds germinate in 7 to 14 days under laboratory conditions, and seedling vigor is excellent. Stands establish rapidly, but stubble mulch, pitting, and furrowing will help establish plantings in arid areas or areas of high erosion. There are 3,300,000 seeds/kg.

Availability/Cultivars: The cultivar Ermelo is used in southern Oklahoma and in part of Texas. Morpha is a winter-hardy selecti that can be used in Oklahoma; Catalina and A-67 cultivars are best adapted to Arizona and New Mexico (Thornberg, 1982).

47. Western wheatgrass (Agropyron smithii)

Distribution: This species occurs from western Washington and Oregon through Nevada and the northern portions of Arizona, New Mexico, and Texas to Ohio (Hitchcock, 1950; Wasser, 1982).

Description: Western wheatgrass is a native, cool-season, C-3, rhizomatous, perennial that grows 30 to 90 cm tall (Beetle, 1977). Growth begins in March and ends in August. Foliage is moderately palatable to livestock and small mammals year-round, but is only palatable to deer in the spring (Shaw and Cooper, 1973).

Ecological Setting: This species is most commonly found on fine to very fine-textured soils that retain moisture longer than coarse-textured soils. However, it is also tolerant of sandy soils and is highly tolerant of poorly drained and saline sites (Wasser, 1982). The optimum MAP zone is 35 to 50 cm, but the species can survive in 13- to 35-cm zones when mesic swales are available (Thornberg, 1982). It is tolerant of fire, moderate

grazing, shade, and drought (Hafenrichter, et al., 1968; Wasser 1982), and is highly competitive once it is established (Plummer, et al., 1955).

Uses: Western wheatgrass offers long-term erosion control and forage for livestock and some big game species. This species is adapted for use at Forts Bliss, Carson, Riley, and Sill.

Establishment: Western wheatgrass should be drill-seeded 1.3 to 2.5 cm deep at 6.5 to 17 kg PLS/ha to produce good stands. Germination capacity ranges from 50 to 80 percent and requires 30 days (Fulbright, et al., 1982). Seedling vigor is fair. Stands must be protected until plants are established. Nitrogen fertilization, irrigation, and mulching can reduce the establishment time. There are 243,000 seeds/kg (Fulbright, et al., 1982), and seeds retain their viability for 2 to 4 years in storage.

Availability/Cultivars: A number of cultivars are available, including Arriba, which is adapted to Colorado. Flintlock and Barton are best for Kansas and parts of Oklahoma. Rosana and Mandan are more appropriate for the northern Great Plains and northern Intermountain regions.

48. Wilman lovegrass (Eragrostis superba)

Distribution: This species grows from southern California to west Texas (Wasser, 1982).

Description: Wilman lovegrass is an introduced, C-4, warm-season, perennial bunchgrass. Culms grow 15 to 120 cm tall (Jordan, 1981; Wasser, 1982). The species has a fibrous root system and its growth begins in early spring. Its palatability and digestibility to livestock are good, rating better than either Boer or Lehmann lovegrasses (Joy, et al., 1972); however, it has little wildlife value.

Ecological Setting: Wilman lovegrass is adapted to sandy loam to clay loam soils (Jordan, 1981; Joy, et al., 1972). It occurs in MAP zones of 23 to 35 cm, and is drought-tolerant, although less so than Lehmann and Boer lovegrasses (Joy, et al., 1972). The species is tolerant of grazing but not of cold.

Uses: This species can be used for forage production and soil stabilization. It is adapted for use at Fort Bliss and could be tested at Fort Irwin.

Establishment: Seeds should be broadcast at rates of 1.1 kg PLS/ha or drilled 0.6 to 1.2 cm deep at 0.6 kg PLS/ha. Irrigation and water trapping will help establish stands. Germination capacity is between 87 and 94 percent (Joy, et al., 1972). Stands should be protected for two growing seasons. There are 2,200,000 to 2,400,000 seeds/kg (Joy, et al., 1972).

Availability Cultivars: The cultivar Palar was released in the early 1970s in Arizona.

49. Yellow Indiangrass (Sorgastrum nutans)

Distribution: Yellow Indiangrass is native to the Great Plains eastward, but is also found in parts of Arizona, Utah, New Mexico, and throughout Texas (Hitchcock, 1950).

Description: Yellow Indiangrass is a native, warm-season, C-4, sod-forming, perennial species that grows 100 to 250 cm tall (Hitchcock, 1950; Wasser, 1982). Growth begins in midspring, and plants mature in late summer or fall. Foliage is highly to moderately palatable to livestock.

Ecological Setting: Yellow Indiangrass is adapted to most soil textures with adequate moisture (Thornberg, 1982). However, it thrives on deep soils. It occurs in MAP zones that exceed 38 cm but is better suited to zones with more than 48 cm (Thornberg, 1982). This species tolerates saline and acid sites (down to pH 4.5), as well as periodic flooding. It is tolerant of cold, moderately tolerant of drought and fire, and slightly tolerant of grazing pressure.

Uses: This species provides good erosion control, pastures under intensive forage production management, and coven for wildlife. Yellow Indiangrass is adapted for use at Forts Carson, Hood, Riley, and Sill.

Establishment: Seeding 8.0 kg PLS/ha at 0.6 to 2.0 cm on a firm seedbed is recommended (Wasser, 1982). Between 35 and 65 percent of seeds germinate in 7 to 28 days (Fulbright, et al., 1982). Mulching, fertilization, and irrigation increase the success of plantings and reduce from 2 years to 1 year the time needed for stands to fully develop. Seedlings show excellent vigor for a warm-season prairie grass (Wasser, 1982). There are 350,000 to 440,000 seeds/kg (Fulbright, et al., 1982), and seeds can be stored 2 to 6 years (Blake, 1935; Wheeler and Hill, 1957).

Availability/Cultivars: Seeds are readily available; cultivars include Cheyenne (Texas panhandle), Llano (New Mexico, Texas panhandle, Oklahoma and southwest Kansas), Nebraska 54 and Oto (Kansas and Nebraska), Osage (central Kansas, western Oklahoma, and northern Texas), and Tejas and Lometa (Texas).

Forbs

1. Alfalfa (Medicago sativa)

Distribution: Alfalfa is cultivated throughout the United States.

Description: Alfalfa is an introduced, cool-season, leguminous, perennial forb. It is a deeply taprooted species that grows 60 to 90 cm tall. Growth begins in early spring; plants mature in late summer, with good regrowth possible. This species provides nutritious forage for livestock and wildlife during the growing season, but management is needed to avoid bloat in ruminants (Plummer, et al., 1968).

Ecological Setting: Alfalfa is adapted to moist, deep, fertile loams with a pH tolerance of 5.5, but grows best on alkaline soils (Hafenrichter, et al., 1968; Wasser, 1982). It is moderately tolerant of saline conditions

and is found in MAP zones that exceed 23 cm (Plummer, et al., 1968). The species is tolerant of drought, fire, and cold. It is moderately tolerant of grazing, and established plants are highly competitive.

Uses: Alfalfa is an important forage species in pastures, is frequently irrigated and cut for hay, and provides erosion control. This species is adapted for use in appropriate areas at Forts Bliss, Carson, Riley, and Sill.

Establishment: Alfalfa is commonly seeded 1.3 to 2.5 cm deep on loams and sands, respectively, at rates of 5 to 11 kg PLS/ha (Townsend and McGinnies, 1972; Wasser, 1982). Seeds germinate 80 to 90 percent in 7 to 28 days; seedling vigor is good to excellent, and stands are fully developed in 2 years (Plummer, et al., 1968; Redente, et al., 1982; Wasser, 1982). Seeds should be inoculated before planting. Irrigation aids establishment in semiarid regions. Seedlings and root cuttings can be transplanted. There are about 500,000 seeds/kg (AOSA, 1978).

Availability/Cultivars: Many cultivars are commonly available, including Rambler, Roamer, Beaver, Ladak, Drylander, Kane, and Vernal.

2. American vetch (Vicia americana)

Distribution: American vetch is found in the northern two-thirds of the United States (Wasser, 1982).

Description: American vetch is a native, cool-season, perennial, leguminous forb. Plants are 10 to 100 cm tall (Harrington, 1979; Wasser, 1982). Growth begins between early spring and early summer, with plants maturing from June through September. Foliage is palatable to livestock, wildlife, and small mammals, and seeds are eaten by game and other birds.

Ecological Setting: The species occurs on moist sandy to clayey soils, but does best on loams. It has a low tolerance for acid and alkaline soils, but is moderately saline-tolerant (Wasser, 1982). It can survive in MAP zones as low as 35 cm in the intermountain and mountain areas; however, on prairies and grasslands, it grows in MAP zones of 50 cm or more. Vetch varies in drought tolerance from moderate to good, varies in shade tolerance from poor to good, is cold-hardy, and has a low tolerance for grazing. American vetch can be highly aggressive in moist situations.

Uses: American vetch fixes nitrogen, is a good erosion control plant, and provides forage for domestic and wild animals. It is adapted for use in appropriate areas at Forts Carson, Riley, and Sill.

Establishment: Seed-drilling at rates of 3.0 to 9.0 kg PLS/ha at 1.3 to 3.0 cm deep is recommended. The deeper planting depths are appropriate for fine-textured dry sites. Seed germination ranges from 60 to 90 percent, and seedling vigor is fair. Seeds should be inoculated before planting. There are 54,000 seeds/kg (Eddleman, 1977).

Availability/Cultivars: Seeds are available in limited quantities, but no cultivars have been released.

3. Cicer milkvetch (Astragalus cicer)

Distribution: Cicer milkvetch is found from central Arizona and New Mexico up through Canada. It also extends through the Dakotas and eastern portions of the west coast states (Wasser, 1982).

Description: Cicer milkvetch is an introduced, warm-season perennial forb with a fibrous root system and short rhizomes. It grows to be 30 to 90 cm tall. Growth begins in the spring, plants mature in the summer, and some regrowth occurs in late summer and fall (Stroh, et al., 1972). Foliage is palatable to livestock, wildlife, and small mammals (Thornberg, 1982).

Ecological Setting: This species is adapted to many different soils, but does best on loams, sandy loams, and calcareous soils (Thornberg, 1982). It is strongly alkaline-tolerant and has low fertility requirements. The species is generally found in MAP zones of 40 to 90 cm (Thornberg, 1982), and is recommended in cooler areas above a 600-m elevation. It has good cold tolerance, and may be fire-resistant. Established plants are competitive on moist sites.

Uses: This is a useful species for forage production and erosion control. It is also a nitrogen-fixing legume and therefore may be of value in maintaining long-term nitrogen levels for associated grass spccies. Cicer milkvetch is adapted for use in appropriate areas at Forts Carson, Riley, and Sill.

Establishment: Drill-seeding at rates of 9 kg PLS/ha 1.3 to 2.0 cm deep on a firm seedbed is recommended. Seeds germinate in 10 to 14 days under optimum conditions, and seedling vigor is fair without irrigation. Irrigation improves seedling vigor, ensures stand establishment, and reduces from 3 years to 2 years the time required for stands to fully develop. Young, et al., (1970) reported 20 percent germination in 28 days. Seeds should be inoculated with mycorrhizae. There are 250,170 to 268,400 seeds/kg (Redente, et al., 1982) and seeds can be stored for 20 years (Plummer, et al., 1968).

Availability/Cultivars: Two cultivars (Lutana and Monarch) have been released. Lutana is curently more readily available.

4. Common yarrow (Achillea millefolium)

Distribution: Common yarrow occurs throughout the United States except for Florida (Wasser, 1982).

Description: Common yarrow is an introduced, cool-season, perennial forb that grows 25 to 90 cm tall (Harrington, 1979; Wasser, 1982). It is rhizomatous and has a fibrous root system. Growth begins in early spring, with plants maturing in the summer. Foliage has poor to moderate palatability and is eaten by browsers and small mammals; birds eat the seeds.

Ecological Setting: Common yarrow is adapted to moist, cool, loamy soils (Sampson, 1914). It is tolerant of poor drainage, flooding, and weakly basic to weakly acidic soils. It occurs in MAP zones that exceed 45 cm (Wasser, 1982). This species is tolerant of cold, fire, and grazing, moderately tolerant of drought and shade, and competitive once established (Wasser, 1982).

Uses: Common yarrow has some application for erosion control and for providing food for some wildlife species. It could be tested in appropriate areas at Forts Carson, Riley, and Sill.

Establishment: Common yarrow should be shallowly planted 0.6 cm deep at rates of 0.5 kg PLS/ha. Germination (16.5 to 78 percent) occurs in 2 to 8 days, and seedling vigor is good (Redente, et al., 1982). Stands require 2 years to develop fully.

Availability/Cultivars: There are no cultivars, and seed sources may be limited.

5. Crownvetch (Coronilla varia)

Distribution: Crownvetch is found in the northern two-thirds of the United States (Wasser, 1982).

Description: Crownvetch is an introduced, cool-season, rhizomatous, perennial forb that is 30 to 120 cm tall. Although is leguminous, it is not known to cause bloat in livestock. Growth begins in the spring, with plants maturing in the summer. Foliage is palatable and nutritious to livestock and wildlife (Leffel, 1973).

Ecological Setting: The species is best adapted to fertile, well-drained, sandy- and silty-textured soils with a lower pH limit of 5.0 (Thornberg, 1982). It has moderate fertility requirements. Crownvetch grows in MAP zones that exceed 35 cm (Thornberg, 1982). Crownvetch does best on southern-exposed sites in northern latitudes. Rhizomes survive drought and fire and also tolerate grazing and shade moderately well. Established plants are competitive (Wasser, 1982) with other species.

Uses: This species provides erosion control, supplies forage for wildlife and livestock, and fixes nitrogen. Crownvetch is adapted for use in appropriate areas at Forts Carson, Riley, and Sill.

Establishment: Drill seeding 1.3 to 2.5 cm deep at rates of 11 to 22 kg PLS/ha is recommended for arid zones (low rate) and mesic zones (high rate) (Wasser, 1982). Seeds germinate in 14 days, although dormancy will greatly reduce the germination percentage. Seedling vigor is fair. Stands may require 3 to 4 years to develop fully. There are 305,000 seeds/kg (AOSA, 1978). Seeds should be inoculated with mycorrhizae before planting.

Availability/Cultivars: The cultivars Emerald, Penngift and Chemung have been released in the east; Emerald has been used with some success in the west.

6. Illinois bundleflower (Desmanthus illinoensis)

Distribution: Illinois bundleflower naturally occurs from southern North Dakota through the eastern half of Texas, and eastward to Florida up to western Ohio (Harrington, 1979; Wasser, 1982).

Description: Bundleflower is a native, warm-season, perennial, leguminous forb that grows 60 to 120 cm tall (Thornberg, 1982). Growth begins in late spring, with plants maturing from August through October. Foliage is palatable to livestock and wildlife, and the seeds are eaten by birds (Graham, 1941).

Ecological Setting: Bundleflower is adapted to a wide variety of soils, but does best on medium-textured soils in moist depressions (Thornberg, 1982). It has a lower-range pH tolerance limit of 5.0, but will tolerate moderately alkaline sites. It commonly occurs in MAP zones of 40 to 50 cm (Thornberg 1982). Bundleflower is tolerant of drought, moderately tolerant of fire and shade, and is susceptible to grazing and cold. It is moderately competitive with other species (Wasser, 1982).

Uses: This species provides forage for livestock and wildlife and supplies cover for some wildlife species. It may be used in appropriate areas at Forts Carson, Hood, Riley, and Sill.

Establishment: The species is readily established from seeds when drilled 1.3 to 2.5 cm deep at rates of 5.5 to 11 kg PLS/ha (Wasser, 1982). Rootstock transplanting can be considered on critical sites. Mulching and irrigation ensure successful establishment. Scarified seeds (1 hour in sulfuric acid) will germinate in 5 to 14 days. Germination capacity has been reported at 84 percent (Swingle, 1939). Seedling vigor is good, and stands become fully established in two growing seasons (Blake, 1935).

Availability/Cultivars: There are no released cultivars; however, seeds are readily available.

7. Lewis flax (Linum lewisii)

Distribution: Lewis flax occurs throughout the western United States in the prairies and mountains.

Description: This species is a native, cool-season, short-lived perennial forb that grows from 30 to 90 cm tall (Wasser, 1982). Growth begins in spring, and plants mature from June through October. When green, Lewis flax foliage provides forage for livestock and wildlife; its seeds are eaten by birds and rodents in the fall and winter (Plummer, et al., 1968).

Ecological Setting: Plants thrive on well-drained soils of a variety of textures (Plummer, et al., 1968). It is tolerant of weakly alkaline and acidic soils and moderately saline soils. This species generally occurs in MAP zones of between 25 and 40 cm (Wasser, 1982). It is winter-hardy, moderately tolerant of grazing and shade, and can be damaged by fire (Plummer, et al., 1968).

Uses: Lewis flax improves diversity in a seed mixture and acts as a limited food source for livestock and wildlife. This species is adapted for use at Fort Carson and could be tested in appropriate areas at Forts Bliss and Sill.

Establishment: Seeds are drilled 0.6 to 2.0 cm deep at rates of 3.5 to 7.0 kg PLS/ha (Wasser, 1982) and germinate in 15 to 30 days. Sseedling vigor is fair, with stands becoming fully developed in two or three growing seasons. There are 512,216 to 929,115 seeds/kg, and seeds can be stored for 3 years (Plummer, et al., 1968; Swingle, 1939).

Availability: Appar is a cultivar adapted to the Intermountain Region. Generally, seeds are commercially available.

8. Maximilian sunflower (Helianthus maximiliana)

Distribution: Maximilian suntlower occurs throughout the Great Plains, from Montana to western Minnesota and south to the Texas gulf coast (Wasser, 1982).

Description: Maximilian sunflower is a native, warm-season, perennial forb with short rhizomes. It grows 90 to 180 cm tall (Wasser, 1982), with growth beginning in late spring, and plants maturing in late summer through October. Its foliage is palatable to livestock and wildlife, and its seeds are preferred by many bird species (Johnson and Nichols, 1970).

Ecological Setting: This species grows best on deep sandy loams to clay loams in MAP zones of 35 cm or more (Thornberg, 1982; Wasser, 1982). It has low to moderate tolerance of acidic, alkaline, and saline soils, and is moderately tolerant of poorly drained soils. The species is tolerant of fire and moderately tolerant of drought and shade, but has low tolerance for grazing and cold (Wasser, 1982). Established plants are highly competitive unless management techniques such as grazing reduce their vigor.

Uses: This species is a useful plant for wildlife food and cover, and provides summer forage for livestock. Maximilian sunflower is adapted for use in appropriate areas at Forts Carson, Hood, Riley, and Sill.

Establishment: Drill-seeding 0.6 to 2.5 cm deep at rates of 3.5 to 7 kg PLS/ha is recommended in mesic areas or in irrigated areas. Seeds germinate in 7 to 14 days; however, dormancy may reduce densities (Wasser, 1982). Seedling vigor is good, with stands developing in one to two growing seasons. There are 448,800 seeds/kg (Swingle, 1939).

Availability/Cultivars: Prairie Gold is an adapted cultivar that is used from southern South Dakota through northern Oklahoma. Aztec was developed for Texas and Oklahoma.

9. Northern sweetvetch (Hedysarum boreale)

Distribution: Northern sweetvetch ranges from the Texas Panhandle northward and westward through North Dakota to eastern Washington (Wasser, 1982).

Description: Northern sweetvetch is a native, cool-season, perennial, leguminous forb. It grows 25 to 60 cm high and has a deep taproot with some lateral roots (Harrington, 1979). Plummer, et al. (1968), report that some ecotypes are rhizomatous. Growth begins in early spring, with plants maturing in July and August (Plummer, et al., 1968; Wasser, 1982). Foliage is highly nutritious and sought by livestock and wildlife throughout the growing season (Plummer, et al., 1968).

Ecological Setting: Northern sweetvetch is adapted to sandy to clayey soils, but is more common on well-drained loams (Redente, 1980; Redente, et al., 1982). It also occurs on rocky hillsides. It is tolerant of pHs within the 7.0 to 8.6 range (Redente, 1980) and of moderate salinity (Wasser, 1982). It occurs in MAP zones of 25 to 46 cm. The species is tolerant of fire, drought, and cold, but has moderate to low tolerance for shade and grazing. It is weakly to moderately competitive.

Uses: Northern sweetvetch provides forage and erosion control and fixes nitrogen. It is adapted for use at Fort Carson, but may be adapted for limited use in appropriate areas at Forts Bliss and Sill.

Establishment: This species is commonly seeded in mixtures at 0.6 to 2.0 cm deep and at rates of 0.5 to 1.1 kg PLS/ha. Seed inoculation helps stand establishment. Prechilled or scarified seeds germinate within 21 days, and seedling vigor is good to excellent. Germination capacity is between 65 and 94 percent (Redente, 1980). Stands are fully developed by the second year. There are 190,000 to 213,000 seeds/kg (Eddleman, 1977) and seeds can be stored for 5 years (Plummer, et al., 1968).

Availability/Cultivars: There are no formal releases, but seeds are commercially available.

10. Purple prairieclover (Petalostemum purpureum)

Distribution: Purple prairieclover occurs from south central New Mexico, throughout the midwest, north into Minnesota, and throughout northcentral Montana (Wasser, 1982).

Description: Purple prairieclover is a native, warm-season, leguminous, perennial forb. It is a taprooted species that becomes 30 to 90 cm tall (Harrington, 1979; Wasser, 1982). Growth begins in midspring, with plants maturing in July and August. Its foliage has fair to low palatability to livestock; however, both its foliage and seeds are eaten by some small mammal and bird species.

Ecological Setting: This species is adapted to a wide range of soil textures, but is found primarily on well-drained, calcareous loams (Thornberg, 1982). It occurs in MAP zones of 30 to 38 cm, but is more commonly found in 40- to 50-cm MAP zones (Thornberg, 1982). It is moderately tolerant of grazing, fire, drought, and shade (Wasser, 1982) and is moderately competitive.

Uses: This species is suitable for increased species diversity, acts as a food source for some wildlife species, and fixes nitrogen. Purple prairieclover is adapted for use at Forts Carson, Riley, and Sill in appropriate areas.

Establishment: Drill-seeding 0.6 to 1.3 cm deep at rates of 3.5 kg PLS/ha is recommended. Prechilled inoculated seeds have the highest germination rate, germinating in 2 to 10 days. Eddleman (1977) reported 95 percent germination capacity. Seedling vigor is fair, and reducing competition from other species improves establishment. There are 768,300 seeds/kg (Swingle, 1939).

Availability/Cultivars: Kaneb is a released cultivar available for use in Nebraska, Kansas, eastern Colorado, Oklahoma, Texas, and New Mexico. White prairieclover (Petalostemum candidum Michx.) is a related species that is not as widely available; however, it is better adapted to the drier sites and coarser soil textures in the southwestern United States than purple prairieclover (Wasser, 1982).

11. Roundhead lespedeza (Lespedeza capitata)

Distribution: Roundhead lespedeza occurs from eastern South Dakota through the eastern half of Texas and eastward to the Atlantic seaboard (Wasser, 1982).

Description: This species is a native, warm-season, perennial, leguminous forb. It grows 45 to 120 cm tall and is deeply rooted. Growth begins in early spring, with plants generally maturing in the fall. Its foliage is palatable to livestock, wildlife, and small mammals (Gleason and Cronquist, 1963). Many species of birds eat the seeds.

Ecological Setting: Roundhead lespedeza is adapted to well-drained sands and to rocky soils. It is tolerant of weakly acid and alkaline soils and is generally found in MAP zones that exceed 50 cm (Wasser, 1982); however, in lower MAP zones, it occurs in depressions and areas where water collects. This species has great ecotypic variation. It is moderately tolerant of drought, cold, and shade, and its tolerance for fire varies from moderate to excellent. It is moderately tolerant of grazing, but cannot withstand heavy grazing (Wasser, 1982). Roundhead lespedeza is moderately competitive with other species.

Uses: Roundhead lespedeza can be used in erosion control and as forage for livestock and wildlife. This species is adapted for use in appropriate areas at Forts Hood, Riley, and Sill.

Establishment: Drill-seeding 0.6 to 1.3 cm deep on a well-prepared seedbed should be done at rates of about 4.5 to 7.0 kg PLS/ha (Wasser, 1982). Seeds for spring planting should be scarified and should be inoculated before they are planted. Seeds germinate in 7 to 22 days, and seedling vigor is moderately good; however, stands require 2 years to become fully established.

Availability/Cultivars: Seeds are comnercially available, but there are no formally released cultivars.

12. Upright prairie coneflower (Ratibida columnaris)

Distribution: This forb occurs throughout the Great Plains states and into eastern Utah and Arizona (Harrington, 1979).

Description: Upright prairie coneflower is a native, warm-season, perennial forb with a shallow taproot (Harrington, 1979). Growth begins in spring, with plants maturing from July through September and attaining a height of 30 to 90 cm (Wasser, 1982). Foliage is palatable to livestock early in the growing season.

Ecological Setting: This species occurs on deep, well-drained loams and on thin, coarse-textured soils (Wasser, 1982). It is tolerant of weakly saline and acid soils and of moderately alkaline sites. Prairie coneflower occurs in MAP zones of 25 to 38 cm. It varies in winter hardiness, is sensitive to fire during the growing season, and is moderately tolerant of grazing. This species is moderately competitive.

Uses: Upright prairie coneflower improves stand and forage diversity and will help control erosion. It is adapted for use at Forts Carson, Riley, and Sill, and could be tested in appropriate areas at Fort Hood.

Establishment: This species is generally seeded 0.6 to 1.3 cm deep in a firm seedbed at rates of 1 to 2.5 kg PLS/ha. The lower rate is appropriate for arid ranges, and the higher rate is best for mesic areas. Controlling of weedy competition and supplying adequate moisture are important to establish this species. Seeds germinate (99 percent) in 7 to 27 days (Eddleman, 1977; Wasser, 1982), and scarification of the seed coat will improve germination rates. Seedling vigor is fair, with stands requiring 2 or 3 years to establish fully. There are 1,616,000 to 1,485,000 seeds/kg (Eddleman, 1977).

Availability/Cultivars: No cultivars have been released to date, and seeds may not be consistently available because collections are made from native stands.

13. White clover (Trifolium repens)

Distribution: White clover occurs throughout the United States (Harrington, 1979).

Description: White clover, also known as white Dutch clover, is an introduced, perennial, leguminous forb. Young plants have taproots that develop into a fibrous root system as the plants age. Growth begins in early spring, with plants attaining heights of 5 to 30 cm (Harrington, 1979). Plants flower from May through July and have good regrowth in the summer. Foliage is palatable to both livestock and wildlife, but may cause bloat in ruminants; seeds are eaten by many bird species.

Ecological Setting: This species grows well on clay to silt loam soils that are well-drained (Hafenrichter, et al., 1968). It has moderate fertility requirements, and is tolerant of weakly alkaline and acidic soils; however, it is intolerant of saline soils (Wasser, 1982). White clover

generally occurs in MAP zones that exceed 50 cm (Thornberg 1982). It is tolerant of grazing and fire (only in the dormant stage) and moderately tolerant of drought, but has low tolerance for shade (Wasser, 1982). The species is moderately competitive.

Uses: White clover provides good-quality forage for livestock and many wildlife species, is an excellent erosion control plant, and fixes nitrogen. It works very well in many general seeding mixtures. This species could be tested in appropriate areas at Forts Hood, Riley, and Sill.

Establishment: Drill-seeding 0.6 to 1.3 cm deep at rates of 2.2 to 4.5 kg PLS/ha in a grass mixture is recommended, and seeds should be inoculated before planting. White clover does not require as intensive a seedbed preparation as other legumes. Seeds germinate (76 percent) in 5 days (Smith, 1940), with seedlings showing low to moderage vigor. Stands require 2 to 3 years to establish completely; irrigation will aid establishment. There are 1,500,000 to 2,000,000 seeds/kg (AOSA 1978) and seeds can be stored for long periods of time (Redente, et al., 1982).

Availability/Cultivars: Several cultivars are readily available, including Ladino, Merit, and Pilgrim.

14. Yellow sweetclover (Melilotus officinalis)

Distribution: Yellow sweetclover is common throughout the United States.

Description: Yellow sweetclover is an introduced, biennial, C-3, leguminous forb. Growth begins in early spring, with plants becoming 60 to 180 cm high by midsummer. Its foliage is palatable and nutritious to livestock and many wildlife species, but can cause bloat in livestock (Thornberg, 1982).

Ecological Setting: This species is adapted to virtually all soil textures and does well on calcareous soils (Thornberg 1982; Wasser 1982). It is primarily adapted to weakly acidic to moderately alkaline soils (Hafenrichter, et al., 1968). It occurs in MAP zones that exceed 40 cm, but is also used in mesic microsites in MAP zones of 25 to 40 cm (Thornberg, 1982; Wasser, 1982). This species is tolerant of fire, drought, and cold and can be an aggressive competitor (Townsend and McGinnies, 1972).

Uses: Yellow sweetclover is commonly used to revegetate roadsites and other disturbed areas and also in forage and hay pastures. This species is adapted for use in appropriate areas at Forts Bliss, Carson, Riley, and Sill.

Establishment: Establishment criteria are similar to those of alfalfa. Yellow sweetclover should be drilled 1.3 to 2.5 cm deep at rates of 2.5 to 4.5 kg PLS/ha, using inoculated seeds to establish mature stands (Wasser, 1982). It is best to plant this species with aggressive, fast-establishing grasses such as wheatgrasses, bromegrasses, or fescues. Seeds germinate in 7 days and have a 71 percent germination capacity (Redente, et al., 1982). Seedling vigor and growth are excellent.

Stands generally can reseed themselves unless there is heavy competition or drought. Irrigation increases the rate of stand establishment and forage yield. There are about 570,000 seeds/kg, and seeds can be stored for long periods (AOSA, 1978; Wheeler and Hill, 1957).

Availability/Cultivars: Seeds are widely available; cultivars common in the United States include Goldtop and Madrid, which are most often used in the west.

Woody Plants

1. Apache plume (Fallugia paradoxa)

Distribution: Apache plume ranges throughout Arizona, New Mexico, southern Utah, Colorado, and west Texas (Deitschman, et al., 1974c; Wasser, 1982).

Description: This species is a native evergreen shrub that grows 1 to 2 m tall (Institute for Land Rehabilitation, 1978; Thornberg, 1982). It has a moderately deep, fibrous root system. Growth begins in early spring and with good precipitation, continues throughout the summer (Wasser, 1982). Foliage has low to fair palatability for deer and other browsers, and improves in the winter.

Ecological Setting: Apache plume occurs on calcareous and rocky soils with textures ranging from sandy to clayey loams. It has a fair tolerance for saline and alkaline soils. It most commonly occurs in the 20- to 50-cm MAP zones (Thornberg, 1982). Apache plume is cold- and drought-hardy, and has moderate tolerance for grazing and fire (Wasser, 1982). Established plants are moderately competitive.

Uses: Apache plume can be potentially useful to stabilize soil, provide wildlife cover, and serve as a limited wildlife food source. It is adapted for use in appropriate areas at Fort Bliss.

Establishment: Recommended planting methods are drilling or broadcasting seeds 0.3 to 0.6 cm deep at 9 to 18 kg PLS/ha (Deitschman, et al., 1974c; Wasser, 1982). Greater than 40 percent germination is possible in 7 to 14 days under laboratory conditions (Deitschman, et al., 1974c; Mirov and Kraebel, 1937) and 60 to 73 percent can be obtained in 60 days (Wasser, 1982). This species has fair germination, weak vigor, and, therefore, poor establishment. Use of stem cuttings (Institute for Land Rehabilitation, 1978) and containerized plants may be the best way to establish stands. There are 924,000 to 1,276,000 seeds/kg, and seeds maintain good viability after 3 years in storage (Deitschman, et al., 1974c; Vories, 1981).

Availability/Cultivars: There have been no cultivars developed, but seeds and transplant materials are available.

2. Big sagebrush (Artemisia tridentata)

Distribution: Big sagebrush occurs from Montana to eastern Washington and south to central California and northwest New Mexico (Wasser, 1982).

Description: This native species is a C-3, evergreen, perennial shrub that grows to 50 to 270 cm tall (Institute for Land Rehabilitation, 1978). It has a well-developed, deep root system that can spread laterally 3 to 4 m (Wasser, 1982). Big sagebrush retains high carbohydrate levels and nutrient content during the winter.

Ecological Setting: Big sagebrush is adapted to most soil textures, but requires deep soils with neutral to slightly basic pHs (Sutton and Johnson, 1974). It has fair salt tolerance and is commonly found in MAP zones of 20 to 40 cm (Wasser, 1982). Mature plants are competitively aggressive, have excellent tolerance for drought, good tolerance for grazing and cold, and poor tolerance for shade and fire.

Uses: Big sagebrush is useful for small mammal and bird cover and as a winter browse species for wildlife and livestock. It is adapted for use in appropriate areas at Fort Carson.

Establishment: Broadcasting seeds at rates of 0.4 kg PLS/ha and covering to a shallow depth are recommended. Mulch, nitrogen, fertilizer, and supplemental water increase the probability of successful establishment (Deitschman, 1974). Germination of 27 percent in 9 days and 80 to 94 percent in 30 days has been reported (Vories, 1981). Seedling vigor is poor, growth is slow, and grass competition will reduce seedling survival. There are 2.4 to 5.5 million seeds/kg, and seeds should not be used after 2 years in storage (Vories, 1981). Transplanting can overcome establishment problems.

Availability/Cultivars: No cultivars have been developed but seeds are commercially available. There are three subspecies of big sagebrush: valley big sagebrush (A. tridentata tridentata), Wyoming big sagebrush (A. tridentata wyomingensis), and mountain big sagebrush (A. tridentata vaseyana).

3. California buckwheat (Eriogonum fasciculatum)

Distribution: This species occurs in the Great Basin and in southwest desert regions (Thornberg, 1982).

Description: California buckwheat is a perennial native shrub that grows 30 to 90 cm tall (Thornberg, 1982). Plants flower from May through October, and fruits ripen from June through August. Its foliage is moderately palatable to livestock (Thornberg, 1982) and is important winter browse for deer (Kay, et al., 1977). It is also valued as a bee plant (Kay, et al., 1977).

Ecological Setting: California buckwheat generally occurs on dry slopes and in canyons (Ratliff, 1974) on sandy to clayey soil textures (Thornberg, 1982). It is adapted to MAP zones of 17.5 to 42.5 cm, and is grazing-resistant and drought-hardy.

Uses: This species is commonly used for steep slope stabilization in arid regions of California. It is adapted for testing at Forts Bliss and Irwin.

Establishment: Seeds can either be broadcast and harrowed to cover or drilled 1.3 cm deep at 180 to 270 seeds/m^2. Germination is generally low (2 to 45 percent), and there are 525,800 to 1,085,000 seeds/kg (Kay, et al., 1977; Ratliff, 1974). Seeds can be stored for 45 months (Ratliff, 1974).

Availability/Cultivars: Seeds are available; however, no cultivars have been developed.

4. Common chokecherry (Prunus virginiana)

Distribution: Common chokecherry is a northern species that extends from southern California northward to Canada, eastward to parts of Georgia and to the Carolinas, and into the northeast United States (Grisez, 1974; Wasser, 1982).

Description: This species is a deciduous shrub or small tree that grows 0.6 to 9 m tall and forms thickets (Watson, et al., 1980). It has a shallow, rhizomatous root system and can sprout from its stump (Wasser, 1982). Growth begins in early spring, fruits ripen from July through September, and leaves fall in late autumn (Grisez, 1974; Wasser, 1982; Watson, et al., 1980). Foliage is palatable to livestock and wildlife and maintains fair nutritional values in the winter; however, it is occasionally toxic to livestock in the late spring and summer (Watson, et al., 1980).

Ecological Setting: Common chokecherry is adapted to most soil textures but does poorly on heavy clays (Wasser, 1982). It is best adapted to sandy to lightly clayey textures (Thornberg, 1982) and is moderately tolerant of basic and acidic soils and of soils with low salinity. This species does best on deep, moist, well-drained, moderately fertile soils and occurs in MAP zones of 30 to 65 cm (Wasser, 1982; Watson, et al., 1980). It has poor to moderate drought tolerance, is tolerant of fire and cold, moderately tolerant of browsing, and highly competitive after establishment.

Uses: This species is a good selection for long-term soil erosion control, wildlife cover, and as a browse plant for wildlife on mesic areas. Common chokecherry is adapted for use or testing in appropriate areas at Forts Bliss, Carson, Hood, Riley, and Sill.

Establishment: Planting seeds 1.0 to 2.5 cm deep at rates of 1 to 2 kg PLS/ha in mixtures of other species is recommended. Seeds planted at a density of 75 seeds/m^2 yielded 3 to 34 percent survival (Wasser, 1982). Seed dormancy can be broken either by prechilling or by seeding before the cold season; 50 to 80 percent germination has been reported under optimum conditions (Vories, 1981). Growth and seedling vigor are only fair (Wasser, 1982). Direct seeding has both succeeded and failed; however transplants of containerized plants and root cuttings have been used with moderate success (Wasser, 1982; Watson, et al., 1980). There are 6600 to 18,500 seeds/kg (Grisez 1974), and seeds can be stored for 5 years (Plummer, et al., 1968).

Availability/Cultivars: No cultivars have been developed, but seeds and transplant material are widely available.

5. Creeping barberry (Berberis repens)

Distribution: Creeping barberry occurs throughout the Rocky Mountain region, extending into eastern Montana and Wyoming, west Texas, Nevada, and eastern Oregon and Washington (Rudolf, 1974a; Wasser, 1982).

Description: Creeping barberry is a native evergreen shrub about 30 cm tall with compound leaves and spreading roots (Thornberg, 1982). It grows throughout the year but is most active in early spring, maturing in the summer and fall (Wasser, 1982). Flowering occurs from April through June, and fruits ripen from August through October (Rudolf, 1974a). Its foliage is consumed by wildlife and small mammals, and its fruit is eaten by birds and small mammals.

Ecological Setting: Creeping barberry occurs on sandy to clayey soils, but is most successful on sandy to silty soils (Thornberg, 1982). It has a low tolerance for alkaline, acidic, and saline soils (Wasser, 1982). The species generally occurs in MAP zones that exceed 38 cm (Thornberg, 1982). It is tolerant of grazing, burning, and shade, is intolerant of flooding, and is moderately competitive (Wasser, 1982).

Uses: Creeping barberry can be used as a wildlife food source and shows promise as a soil stabilization species. It could be tested in appropriate areas at Forts Bliss and Carson.

Establishment: Planting seeds 0.6 to 1.3 cm deep at 15.6 kg PLS/ha is recommended. Prechilled seeds (70 percent) germinate in 10 days and average 62 percent germination after 150 days under laboratory conditions (McLean, 1967; Plummer, et al., 1968). Sufficient moisture and reduction of competition are important for successful seeding. Transplanting is another establishment method, but its success will also require reduced competition and sufficient soil moisture. There are 136,400 seeds/kg (Plummer, et al., 1968; Rudolf, 1974a).

Availability/Cultivars: No cultivars have been developed, but young plants are commercially available.

6. Douglas rabbitbrush (Chrysothamnus viscidiflorus)

Distribution: Douglas rabbitbrush occurs from eastern Washington, Oregon, and California, through Montana, Wyoming, western Colorado, and New Mexico (Wasser, 1982).

Description: Douglas rabbitbrush is a native, deciduous shrub with a deep, wide-spreading root system that grows to 10 to 240 cm tall (Harrington, 1979). Growth begins in the spring, with plant maturity beginning in the fall and continuing throughout the winter. Foliage has low palatability and moderate nutrient levels, but is eaten to some extent by livestock and wildlife.

Ecological Setting: Douglas rabbitbrush is adapted to most soil textures, from clayey saline bottomlands to well-drained sandy soils (Institute for Land Rehabilitation, 1978). Sutton and Johnson (1974) found that it was best adapted to medium- and fine-textured soil. It is weakly tolerant of

both acidic soils and alkaline soils, and is found in 15- to 50-cm MAP zones (Sutton and Johnson, 1974; Wasser, 1982). It is tolerant of drought, fire, and grazing, has some variation in winter hardiness, and is moderately competitive.

Uses: This species is best adapted for erosion control and soil stabilization. Douglas rabbitbrush could be tested in appropriate areas at Forts Bliss and Carson.

Establishment: Seeds should be planted no deeper than 0.6 cm at rates of 0.25 to 0.5 kg PLS/ha in complex seed mixtures (Wasser, 1982). Eddleman (1977) reported seed germination of 50 percent in 3 days, with a potential of . percent, under laboratory conditions. Seedling vigor is good (Plummer, et al., 1968), but stands will take several years to mature fully. Seeds should not be kept more than 2 years because of decreasing viability. There are 1,482,800 to 1,848,000 seeds/kg (Deitschman, et al., 1974b). Transplant materials have been used successfully.

Availability/Cultivars: No cultivars have been developed, but seeds are readily available.

7. Fourwing saltbush (Atriplex canescens)

Distribution: Fourwing saltbush occurs from southern California to central Texas and northward to the Canadian border (Harrington, 1979; Wasser, 1982).

Description: Fourwing saltbush is a native, warm-season shrub that grows to 20 to 250 cm tall (Harrington, 1979). It has a deep, extensively branching taproot, and is deciduous in its northern range and evergreen in milder climates. This species is generally dioecious; however, a small percentage of plants can change sex, depending on the environment. Growth begins in the late spring, with plants maturing in the fall. Fourwing saltbush is highly palatable and nutritious to livestock, deer, and other browsers throughout the year.

Ecological Setting: This species is adapted to a wide variety of soil textures and has good tolerance for alkaline and saline soils (Stark, 1966; Thornberg, 1982). It is commonly found in 15- to 30-cm MAP zones (Stark, 1966; Thornberg, 1982). Fourwing saltbush is highly tolerant of cold, drought, and fire, and moderately tolerant of grazing and temporary flooding (Wasser, 1982). It is also a rapidly establishing shrub that is moderately competitive with grasses.

Uses: Fourwing saltbush is frequently used to revegetate disturbed areas. It provides browse for livestock and wildlife, moderate wildlife cover, and erosion control. This species is adapted for use at Forts Bliss and Carson and could be tested in appropriate areas at Fort Irwin.

Establishment: Dewinged seeds can be drill-seeded 1.3 to 2.5 cm deep (Vories, 1981) at rates of 3.5 to 7.0 kg PLS/ha (Wasser, 1982). Seeds should be dewinged before planting. Germination varies from 44 to 94 percent in 30 days (Vories, 1981). Seedlings emerge in 6 to 20 days under nursery conditions and are relatively tolerant of drought stress (to seven atmospheres); however, drought will delay and reduce germination. Stands require 2 to 3 years to become fully established. Fourwing saltbush can also be established using bareroot and containerized plant stock. This method is appropriate for exceptionally harsh sites. There are 28,600 to 325,600 seeds/kg with an average of 114,400 seeds/kg (Foiles, 1974). Seeds remain viable for more than 5 years in storage (Vories, 1981).

Availability/Cultivars: Three cultivars are available: Marana for southern California through west Texas; Wytana for Montana, Wyoming, and the Dakotas; and Rincon, which will be released soon, for the area between the ranges of the Marana and Wytana cultivars.

8. Fringed sagewort (Artemisia frigida)

Distribution: Fringed sagewort ranges from eastern Washington, Oregon, and Nevada to the western Great Lakes, and south and east into northern Arizona, New Mexico, west Texas, the Oklahoma panhandle, western Kansas, and Iowa (Harrington, 1979; Wasser, 1982).

Description: Fringed sagewort is a native, cool-season, perennial half-shrub which has a moderately deep taproot. Growth begins in late winter to early spring, and plants set seeds in the fall. Stems are annually developing structures that become 10 to 40 cm tall (Harrington, 1979). This species is relatively nutritious in the winter; however, it has only poor to fair palatability to livestock and browsers (Wasser, 1982).

Ecological Setting: Fringed sagewort occurs on coarse- to fine-textured, well-drained soils (Sutton and Johnson, 1974). It is also common on shallow, gravelly soils that are weakly acidic to moderately alkaline. It does well in MAP zones of 20 to 50 cm (Wasser, 1982). Fringed sagewort appears to be a poor competitor and does well in open, disturbed communities. This species is tolerant of drought and grazing, but has low fire tolerance (Plummer, et al., 1968).

Uses: Fringed sagewort has limited use as either forage supply or a soil stabilizer. It is adapted for use in appropriate areas at Forts Bliss, Carson, and Sill.

Establishment: Like many Artemisia species, the seeds of fringed sagewort are small and should be planted near the soil surface at rates of 0.2 to 0.3 kg PLS/ha in complex seed mixtures. Sufficient soil moisture is critical for germination. Seeds germinate in 5 to 12 days under laboratory conditions (Wasser, 1982). Seedlings are drought-hardy but stands require 3 years to mature fully in arid environments. There are 9,979,200 seeds/kg, and seeds can be stored for 2 years (Plummer, et al., 1968).

Availability/Cultivars: There are no developed cultivars, and seed availability is limited. Transplant material is available on a limited basis.

9. Golden currant (Ribes aureum)

Distribution: Golden currant ranges from the Dakotas south into western Nebraska, Colorado, and the Texas Panhandle, and west to northern Arizona and southern California (Harrington, 1979; Wasser, 1982).

Description: Golden currant is a native, deciduous, perennial shrub that grows 0.9 to 3.0 m tall (Harrington, 1979; Institute for Land Rehabilitation, 1978; Thornberg, 1982). Growth begins in the early spring, and fruits mature in June and July (Pfister, 1974). This species develops an extensive, rhizomatous root system. Its foliage has good palatability for wildlife browsers, but is only fair for livestock. Birds eat the fruits.

Ecological Setting: Golden currant is associated with fertile, moist, well-drained silty and loamy soils and occurs in MAP zones of 40 to 50 cm (Thornberg, 1982). It has poor tolerance for salt (Institute for Land Rehabilitation, 1978) and a narrow pH tolerance (6.5 to 7.0) (Sutton and Johnson, 1974). It is tolerant of cold and grazing, moderately tolerant of shade, drought, and fire, and is moderately competitive (Wasser, 1982).

Uses: Golden currant provides cover for game birds and other wildlife species, browse for wildlife and livestock, and soil stabilization on mesic sites. It is adapted for use at Forts Bliss, Carson, and Sill, and could be tested in appropriate areas at Fort Riley.

Establishment: Planting 0.6 to 1.2 cm deep at rates of 0.5 to 1.0 kg PLS/ha is recommended for seeding in complex seed mixtures (Pfister, 1974; Wasser, 1982). Mulching will aid establishment and seedling survival. Germination is slow (60 percent in 60 days under laboratory conditions), but vigor and growth rate are good (Pfister, 1974). Prechilling seeds aids germination of spring seedings. Grazing and competition should be reduced (Wasser, 1982) to ensure good stand establishment. Golden currant has potential problems with bacterial disease, but resistant strains are available. Transplanting is also successful in establishing this species. There are 512,600 seeds/kg, and seeds can be stored 5 to 17 years (Pfister, 1974; Plummer, et al., 1968).

Availability/Cultivars: No cultivars have been developed. Seeds and transplanting materials are commercially available.

10. Green ephedra (Ephedra viridis)

Distribution: Green ephedra ranges from central California to western Colorado and northern Arizona and into New Mexico (Thornberg, 1982; Wasser, 1982).

Description: Green ephedra is a native shrub with short, inconspicuous leaves that grows to 60 to 180 cm tall (Thornberg, 1982). Its stems remain green throughout the year, but leaves are deciduous. This species is palatable to livestock and wildlife browsers (Institute for Land Rehabilitation, 1978; Thornberg, 1982).

Ecological Setting: Green ephedra is adapted to coarse-textured, droughty, rocky soils (Stark, 1966; Wasser, 1982). It also occurs in clayey soils at reduced vigor (Thornberg, 1982). It tolerates slightly alkaline and saline soils (Wasser, 1982). This species is found in 15- to 50-cm MAP zones and is highly drought-tolerant (Thornberg, 1982; Wasser, 1982). It is moderately tolerant of cold and shade, but has poor fire tolerance, and is not competitive with dense grasses.

Uses: Green ephedra is a useful browse species and improves winter forage quality. It could be tested in appropriate areas at Forts Bliss, Carson, and Irwin.

Establishment: Planting 1 to 2 cm deep at rates of 0.6 kg PLS/ha is recommended for seeding ephedra in complex seed mixtures. Young, et al., (1970), reported 58 percent germination in 12 days and 77 to 87 percent germination in 30 days. Seedling vigor and growth are poor, so plants must be protected from competition and browsing until well-established. There are 39,600 to 55,000 seeds/kg (Vories, 1981), and seeds can be stored for up to 5 years (Plummer, et al., 1968).

Availability/Cultivars: No cultivars have been developed; however, seeds are commercially available.

11. Leadplant amorpha (Amorpha canescens)

Distribution: Leadplant amorpha occurs throughout the Great Plains and the Great Lakes region as well as in Arkansas, Texas, and New Mexico and along the gulf coast (Harrington, 1979; Wasser, 1982).

Description: This species is a native, warm-season, leguminous, perennial half-shrub (Thornberg, 1982). It grows from 30 to 120 cm tall, has compound leaves, and has a deep, fibrous root system (Harrington, 1979; Wasser, 1982). Growth begins in early May, and the plant matures in June and July, maintaining green foliage until the first frost (Brinkman, 1974a; Wasser, 1982). Leadplant amorpha supplies nutritive, palatable forage for wildlife browsers and livestock, and also provides wildlife cover. Its seeds are eaten by many species of birds and rodents.

Ecological Setting: Leadplant amorpha occurs on deep sandy to silty soils that are weakly acidic to moderately alkaline (Wasser, 1982) and on clayey soils (Thornberg, 1982). It is found in MAP zones of 38 to 50 cm (Thornberg, 1982; Wasser, 1982) and is competitive with other plants. This species is moderately tolerant of cold, drought, and shade and has good fire tolerance, but is intolerant of heavy grazing.

Uses: Leadplant amorpha is useful for erosion control, forage production and nitrogen fixation. It could be tested in appropriate areas at Forts Carson, Hood, Riley, and Sill.

Establishment: Seeds planted no deeper than 0.6 cm (Brinkman, 1974a) at rates of 14.5 to 18.0 kg PLS/ha have been recommended for pure stands (Wasser, 1982). This species can also be transplanted, using either stem cuttings or rooted transplants. Seeds germinate in 20 days under field conditions, with 30 percent germination reported for laboratory conditions. Stands are slow to establish fully by seeds, so successful plantings have not been common (Wasser, 1982). Therefore, transplanting is recommended over seeding. As with most shrub species, reduction of competition is important during establishment. There are 193,600 to 651,200 seeds/kg (Vories, 1981), and seeds have been stored for 3 years with no loss in viability (USDA, Forest Service, 1942).

Availability/Cultivars: There are no developed cultivars, but plants are available from nurseries specializing in native and wild plants.

12. Mexican cliffrose (Cowania mexicana var. stansburiana)

Distribution: Mexican cliffrose occurs in parts of southern Nevada, Utah, southwest Colorado, most of Arizona, and western New Mexico (Wasser, 1982).

Description: Mexican cliffrose is a native evergreen shrub that grows 1 to 6 m tall (Thornberg, 1982; Wasser, 1982). Growth begins in late winter to early spring, flowering occurs from May through June, and fruits mature from July through the fall (Alexander, et al., 1974; Wasser, 1982). This species is generally nutritious and palatable to wildlife and livestock during the winter.

Ecological Setting: Cliffrose most often occurs on shallow calcareous soils of sandy to silty texture (Thornberg, 1982) and on rocky or coarse soils (Sutton and Johnson, 1974) with pHs between 7.0 and 8.0 (Stark, 1966). It occurs in MAP zones of 25 to 50 cm (Thornberg, 1982). The species is lightly tolerant of drought and winter browsing, moderately tolerant of shade, and intolerant of fire (Wasser, 1982). Once established, it is competitive.

Uses: Mexican cliffrose is adapted to stabiliizing shallow, rocky, southfacing slopes, and provides cover and browse for wildlife. This species could be tested in appropriate areas at Fort Bliss and Carson.

Establishment: Drill-seeding 0.6 to 2.5 cm deep (Alexander, et al., 1974; Wasser, 1982) at rates of 7.0 to 9.0 kg PLS/ha in pure stands or 1 to 2 kg PLS/ha in complex seed mixtures is recommended. Prechilled seeds have 89 to 100 percent germination in 10 to 90 days under laboratory conditions (Vories, 1981); seedling vigor is fair. Plants are slow to develop, taking several years to mature, so reducing competition is critical. Transplanting 16- to 20-week-old plants is an alternative to seeding (Plummer, et al., 1968). There are about 133,760 to 147,400 seeds/kg, and seeds can be stored for 7 years (Alexander, et al., 1974).

Availability/Cultivars: There are no improved cultivars, but seeds and transplant materials are commercially available.

13. Prostrate summer cypress (Kochia prostrata)

Distribution: This species ranges from southeast Oregon, Nevada, and Utah to southern Idaho, southwestern Wyoming, and western Colorado (Wasser,. 1982).

Description: Prostrate summer cypress is a recently introduced, perennial, half-shrub species. It grows 30 to 120 cm tall and has a deep taproot system (Keller and Bleak, 1974; Larrin, 1956). It has variable palatability, which is generally classified as moderate to good (Keller and Bleak, 1974; Larrin, 1956; Wasser, 1982).

Ecological Setting: Prostrate summer cypress is adapted to sandy and other coarse-textured soils (Keller and Bleak, 1974). It is tolerant of saline and sodic soils and has low fertility requirements (Wasser, 1982). This species occurs in 20- to 45-cm MAP zones (Larrin, 1956) and has excellent drought tolerance (Wasser, 1982). Prostrate summer cypress is resistant to fire, competitive, moderately tolerant of grazing and cold, and intolerant of shade (Larrin and Gordeeva, 1960; Wasser, 1982).

Uses: This species shows excellent promise both as a browse plant for animals and as a soil stabilizer. Prostrate summer cypress could be tested in appropriate areas at Forts Bliss and Irwin.

Establishment: Seeds should be broadcast at 0.6 to 11 kg PLS/ha and harrowed or drilled at a shallow depth (0.6 cm) at 3.5 to 4.5 kg PLS/ha (Wasser, 1982). Germination is fair to good, and seedling vigor is good (Larrin and Gordeeva, 1960). There are 1,100,000 seeds/kg, and seeds should not be stored longer than 1 year (Keller and Bleak, 1974).

Availability/Cultivars: Seed availability is limited, and no cultivars have been formally released.

14. Rubber rabbitbrush (Chrysothamnus nauseosus)

Distribution: Rubber rabbitbrush occurs from eastern Washington, Oregon, and California, eastward to the Dakotas, Colorado, and west Texas (Wasser, 1982).

Description: This species is a native, deciduous, erect shrub with a deep root system (Institute for Land Rehabilitation, 1978; Wasser, 1982). Growth begins in the spring, and fruit matures in the fall. This plant grows to be 0.3 to 2.7 m tall (Thornberg, 1982). Rabbitbrush is palatable to livestock and wildlife browsers, and maintains fair nutrient levels through the winter (Plummer, et al., 1968).

Ecological Setting: Rubber rabbitbrush is adapted to open disturbed communities on well-drained alkaline sites with pH ranges of 7.0 to 8.5 (Stark, 1966). It grows on all soil textures (Thornberg, 1982) and has fair salt tolerance (Institute for Land Rehabilitation, 1978). This species is common in MAP zones of 15 to 50 cm (Wasser, 1982). Once

established, it is tolerant of cold, fire, and grazing, and is moderately competitive, but has poor shade tolerance.

Uses: Rubber rabbitbrush is used to revegetate depleted big-game range to provide forage and cover for big game and other wildlife. It is also useful for soil stabilization. This species is adapted for use in appropriate areas at Forts Bliss and Carson.

Establishment: When part of a complex seed mixture, seeds should be shallowly drilled at 0.5 to 1.0 kg PLS/ha. Seeds have high germination potential (Institute for Land Rehabilitation, 1978; Vories, 1981), and seedlings are vigorous with rapid growth; however, stands require 4 years to mature (Wasser, 1982). Use of stem cuttings is a poor technique for establishing this species, but containerized plants have done well in arid areas. There are 737,000 to 1,524,600 seeds/kg, and seeds can be stored for 2 years (Vories, 1981).

Availability/Cultivars: There are no released cultivars but several subspecies are available. Chrysothamnus nauseosus albicaulis and C. n. consimilis are adapted to salt desert shrub areas of the Great Basin. C. n. leiosperma and C. n. hololeucus are adapted to valleys, and C. n. nauseosus and C. n. graueolens are found on the plains and in the mountains (Wasser, 1982).

15. Siberian peashrub (Caragana arborescens)

Distribution: Siberian peashrub occurs from central Nevada and eastern Oregon and Washington to Nebraska, western Iowa, and western Wisconsin (Dietz and Slabaugh, 1974; Wasser, 1982).

Description: Siberian peashrub is an introduced, leguminous, deciduous, large shrub. It begins growing in the spring, produces fruit throughout the summer, and reaches a height of 21.5 m (Dietz and Slabaugh, 1974). Its fibrous root system is extensive and moderately deep. Foliage has low palatability, but the shrub provides some cover for wildlife (Thornberg, 1982).

Ecological Setting: Siberian peashrub is found on sandy to clayey-textured soils, but commonly occurs on sandy to silty textures (Thornberg, 1982), with a wide pH range (4.0 to 11.0) (Vories, 1981). This species occurs in MAP zones of 25 to 50 cm (Thornberg, 1982; Wasser, 1982). It is highly tolerant of drought and cold, has low grazing tolerance, and is intolerant of fire (Dietz and Slabaugh, 1974; Plummer, et al., 1968; Wasser, 1982). Plants are competitive with herbaceous species.

Uses: This species has been used for wildlife cover and for windbreaks. Siberian peashrub is adapted for use in appropriate areas at Forts Carson, Riley, and Sill.

Establishment: Seeds planted 0.6 to 2.3 cm deep in a well-prepared seedbed at rates of 75 to 150 seeds per linear meter are recommended for nurseries (Dietz and Slabaugh, 1974; Wasser, 1982). Survival will be 35 to 50 percent under these conditions. Germination capacity is 55 to 100 percent (USDA, Forest Service, 1948), with seeds germinating in 21 days under lab

conditions. Stands mature in 3 to 5 years. Root cuttings and transplants can also be used to establish this species; however, container plants grown for 1 to 2 years are recommended (Dietz and Slabaugh, 1974). Protecting young plants from competition and animal browsing will improve their chances of survival. Seeds can be stored for several years, and there are 39,600 to 41,800 seeds/kg (Dietz and Slabaugh, 1974).

Availability/Cultivars: There are no formal cultivar releases; however, informal varieties are recognized for horticultural use, and seeds and plant materials are widely available (Wasser, 1982).

16. Silver buffaloberry (Shepherdia argentea)

Distribution: Silver buffaloberry occurs in the northern and central Great Plains, the Intermountain West, the Great Basin of Utah and Nevada, and western California (Wasser, 1982).

Description: This species is a rhizomatous, deciduous, native shrub that forms thickets 1.8 to 4 m high (Wasser, 1982). Its root system is shallow and extensive. Growth begins in the spring, flowers form in April and June, and fruits mature from June through December. Foliage and twig palatability to livestock and wildlife browsers is low to moderate.

Ecological Setting: Silver buffaloberry is adapted to deep, well-drained sandy- through clayey-textured soils with pH ranges of 7.0 to 8.0 (Stark, 1966, Sutton and Johnson, 1974). It occurs in MAP zones of 30 to 50 cm (Thornberg, 1982). It is moderately tolerant of saline soils and fire, tolerant of cold temperatures and grazing, and strongly competitive (Thilenius, et al., 1974; Wasser, 1982).

Uses: Silver buffaloberry is potentially useful for providing soil stability and wildlife cover, but has limited wildlife browse potential. It could be tested in appropriate areas at Forts Bliss, Carson, Riley, and Sill.

Establishment: Seeds should be planted 0.6 cm deep and covered by 1.3 to 2.5 cm of crimped straw mulch (Thilenius, et al., 1974). However, planting seeds 2.0 cm deep without mulch may also be appropriate (Wasser, 1982). Survival of plants from seeds is about 5 to 15 percent (Wasser, 1982), and seeding rates of 1 to 2 kg PLS/ha are recommended. This species displays fair growth, establishment, and seedling vigor. Transplanting may improve the time needed to establish stands and also improve survival. There are 39,600 to 147,400 seeds/kg, and seeds can be stored for 5 years (Vories, 1981).

Availability/Cultivars: There are no developed cultivars, and commercial stock may be somewhat limited.

17. Skunkbush sumac (Rhus trilobata)

Distribution: Skunkbush sumac occurs from Illinois west to the Washington and Oregon borders, southward to the California coast, and into western portions of Texas, Oklahoma, and Kansas (Brinkman, 1974b; Wasser, 1982).

Description: This species is a native, deciduous shrub that is rhizomatous and forms thickets 0.6 to 4.6 m high (Thornberg, 1982; Wasser, 1982). Growth begins in the spring, fruits mature from June through September (Vories, 1981), and leaf drop occurs during fall and early winter (Wasser, 1982). The species is of low palatability to livestock and has moderate to good palatability for big-game browsers. Its seeds are consumed by many bird species (Plummer, et al., 1968).

Ecological Setting: This species is adapted to sandy through clayey soils, but does best on sandy-loam to clayey-loam soils (Thornberg, 1982). It generally occurs on dry sites (Institute for Land Rehabilitation, 1978) in MAP zones of 20 to 50 cm (Thornberg, 1982). Skunkbush sumac is tolerant of fire and grazing, moderately tolerant of drought and shade, and has a low tolerance for saline soils (Wasser, 1982). Once established, plants are moderately competitive.

Uses: Skunkbush sumac is a good soil stabilizer on coarse, dry soils, and provides cover, browse, and seed for wildlife. It is adapted for use at Forts Carson, Sill, and Riley and could be tested in appropriate areas at Fort Bliss.

Establishment: Planting seeds 0.6 to 2.0 cm deep at rates of 1 to 2 kg PLS/ha is recommended for complex seed mixtures (Wasser, 1982). Germination of 61 percent in 15 days under laboratory conditions has been reported (Brinkman, 1974b); however, field germination and initial establishment have been considered poor. Growth rate is considered to be only average, with stands taking as long as 10 years to mature (Plummer, et al., 1968). Root and stem cuttings and containerized plants can partially overcome these establishment problems. Seeds are viable for 5 years in storage (Plummer, et al., 1968), and there are 52,800 to 277,200 seeds/kg (Brinkman, 1974b).

Availability/Cultivars: Plant material and seeds are widely available. Bighorn skunkbush sumac is a cultivar developed in New Mexico and is adapted for the area from New Mexico to Montana and east to North Dakota (Thornberg, 1982).

18. True mountain mahogany (Cercocarpus montanus Ref.)

Distribution: True mountain mahogany ranges throughout California and southern Oregon, and westward into southern Idaho, Wyoming, and west Texas (Wasser, 1982).

Description: True mountain mahogany is a native deciduous shrub that is 1 to 3 m tall and has an extensive, deep root system (Harrington, 1979). Plants begin growing in March, flower in May to June, and in southern climates, retain leaves throughout the winter. The species is highly

palatable to deer and other browsers, moderately palatable to livestock, and moderately nutritious in the winter.

Ecological Setting: This species occurs on well-drained sandy to clayey soils (Thornberg, 1982). It is is adapted to thin, rocky soils, and is tolerant of weakly acidic and weakly alkaline soils (pH 6.5 to 7.5) (Sutton and Johnson, 1974). True mountain mahogany occurs in MAP zones of 14 to 50 cm (Institute for Land Rehabilitation, 1978) but does best in MAP zones that exceed 27 cm (Thornberg, 1982). It has poor salt tolerance (Institute for Land Rehabilitation, 1978), but is tolerant of cold, fire, and winter browsing, and moderately tolerant of drought (Plummer, et al., 1968; Wasser, 1982). Once established, this species is competitive.

Uses: This species provides good soil erosion protection on relatively dry slopes and is an important winter food source for deer. It is adapted for use in appropriate areas at Fort Carson.

Establishment: Seeds are planted 0.6 to 1.3 cm deep at rates of 0.2 to 1 kg PLS/ha. Under laboratory conditions, seeds germinate in 9 days. Germination rates of 86 to 92 percent were achieved in 70 days under conditions similar to those in the field (Deitschman, et al., 1974a). Plants are slow-growing and require several years to mature; thus, reduction of competition is important for seedling survival. Seedlings are probably weakly competitive. Transplants have been used at some sites, but still require several years to develop into large specimens. There are 123,000 to 143,000 seeds/kg (Deitschman, et al., 1974a), and seeds can be stored 5 to 7 years (Vories, 1981).

Availability/Cultivars: Montane is a cultivar recently released in New Mexico. Native seeds are abundant and are suitable for use in areas compatible with the seed collection sites.

19. Western snowberry (Symphoricarpos occidentalis)

Distribution: This species is distributed from eastern Washington to the Great Lakes, and south throughout the Great Plains and Intermountain West (Evans, 1974; Wasser, 1982).

Description: Western snowberry is a native, deciduous shrub that is rhizomatous and forms thickets 0.5 to 1.2 m high (Harrington, 1979). Growth begins in the spring, flowers occur from June through July, and fruits mature in the fall (Evans, 1974). Palatability is fair for livestock and good for wildlife browsers (Wasser, 1982). Many species of birds eat the fruits.

Ecological Setting: Western snowberry is adapted to slightly acidic to moderately alkaline sandy and silty clay loams (Watson, et al., 1980). It is moderately tolerant of salinity, and is tolerant of poorly drained soils. It is strongly drought-tolerant and occurs in MAP zones of 30 to 50 cm (Wasser, 1982). It has good tolerance for grazing and fire and moderate tolerance for shade. Western snowberry is highly competitive with other species.

Uses: This species provides excellent erosion control, as well as forage and cover for many prairie wildlife species. Western snowberry could be tested in appropriate areas at Forts Carson, Riley, and Sill.

Establishment: Planting seeds 0.6 to 2.0 cm deep is recommended (Evans, 1974). Field germination has been low, and seeding rates have not yet been tested (Wasser, 1982). However, because of its rapid growth and aggressive, competitive nature (Bailey, 1972), transplants, cuttings, root stock, or containerized plants should provide excellent stands. There are 114,400 to 216,000 seeds/kg (Vories, 1981), and seeds can be stored for long periods at cool temperatures (Evans, 1974).

Availability/Cultivars: No cultivars have been developed, and quantities of seeds and planting stock may be limited (Thornberg, 1982).

20. Western virginbower (Clematis ligusticifolia)

Distribution: Western virginbower ranges from the Dakotas southward into the Oklahoma panhandle area and New Mexico, and to the Pacific coast except for southern parts of California, Nevada, and Arizona in the Mojave and Sonoran Deserts (Harrington, 1979; Wasser, 1982).

Description: Western virginbower is a native, herbaceous vine with a woody base (Thornberg, 1982). It has a shallow, fibrous root system, and its stems grow from 3 to 6 m long (Harrington, 1979). Growth begins in the spring, flowering occurs in March, and fruits mature from May through December. It has low palatability to deer and livestock, but is browsed slightly by deer (Plummer, et al., 1968).

Ecological Setting: Western virginbower is adapted to sandy through clayey textures but does best on silty to clayey soils (Thornberg, 1982). It is weakly tolerant of basic, acidic, and saline sites (Wasser, 1982), and is common in 25- to 50-cm MAP zones (Thornberg, 1982). The species is associated with mesic microsites. It is sensitive to drought and fire, has moderate tolerance for shade and frost, and appears to be moderately low in competitive ability (Wasser, 1982).

Uses: Western virginbower is best adapted for soil stabilization in nonsaline mesic sites. It could be tested in appropriate areas at Forts Carson, Hood, Riley, and Sill.

Establishment: Seeds in a complex mixture should be sown 1.3 to 2.5 cm deep at rates of 1 kg PLS/ha; grass seeds should comprise less than 50 percent of the total mixture (Wasser, 1982). Under laboratory conditions, 11 to 84 percent germination is possible after 200 days (Rudolf, 1974b). Seeding in moist sites and reducing competition from annual weedy species will aid in survival. Seeds are viable for 2 years, and there are 660,000 to 721,600 seeds/kg (Rudolf, 1974b).

Availability/Cultivars: There are no improved cultivars, and large seed collections may be difficult to locate.

21. Winterfat (Ceratoides lanata)

Distribution: Winterfat occurs from the western edge of the Great Plains and west Texas to eastern Washington, Oregon, and California (Wasser, 1982).

Description: Winterfat is a native, cool-season, half-shrub that is 30 to 100 cm tall (Harrington, 1979). It has a deep taproot and an extensive fibrous root system (Institute for Land Rehabilitation, 1978). Winterfat begins growing in the spring and matures throughout the fall. It is highly palatable and nutritious to livestock and to many species of wildlife; it also provides some cover for small mammals and birds.

Ecological Setting: This species is adapted to a wide range of soil textures (Wasser, 1982) and can occur in pure stands in calcareous valley bottoms (Thornberg, 1982). It is moderately tolerant of saline sites and intolerant of acidic soil, preferring pHs of 7.4 to 8.0 (Woodmansee and Potter, 1971). The species is intolerant of flooding and is common in MAP zones of 12 to 50 cm (Stark, 1966; Thornberg, 1982). It is highly tolerant of drought, cold, and fire, and moderately tolerant of grazing; however, continuous use of an area can eliminate this species. Winterfat is shade-intolerant (Woodmansee and Potter, 1971) and is moderately competitive with grasses.

Uses: This species provides good erosion control and excellent winter forage for livestock and wildlife. It is adapted for use in appropriate areas at Forts Bliss and Carson.

Establishment: Broadcasting or drill-seeding 0.3 to 0.6 cm deep at rates of 4.5 to 6.0 kg PLS/ha is recommended (Vories, 1981; Wasser, 1982). Seeds should be broadcast in front of a drill seeder, because the seeds are fluffy and require a shallow planting depth. Good seedbed preparation, mulching, and reducing competition from other plants help stands become established (Wasser, 1982). Germination in 5 to 30 days is usually high (60 to 100 percent) (Vories, 1981). There are 244,200 to 462,000 seeds/kg (Vories, 1981), and seeds can be stored no longer than 6 months before germination capacity is significantly reduced.

Availability/Cultivars: No cultivars have been developed, but seeds are widely available from native stands.

22. Woods rose (Rosa woodsii)

Distribution: Woods rose ranges from Wisconsin to eastern Washington and Oregon, and south to west Texas and central Arizona (Wasser, 1982).

Description: Woods rose is a shallow-rooted, rhizomatous, deciduous, native shrub that forms thickets 0.5 to 3 m tall (Harrington, 1979; Wasser, 1982). Growth begins in the spring, flowering occurs from May through August, and fruits ripen in July and August (Gill and Pogge, 1974). This species is moderately palatable to livestock and wildlife browsers, and its fruits are eaten by birds and small mammals during the winter.

Ecological Setting: This species is adapted to well-drained loams and sands that are moderately acidic to slightly alkaline (Stark, 1966; Wasser, 1982). Woods rose occurs in MAP zones of 30 to 50 cm, but does best with a minimum precipitation of 40 cm. Its tolerance for shade and drought is moderate, and its tolerance for fire and grazing is high. It is moderately to strongly competitive and readily invades disturbed sites.

Uses: Woods rose provides forage, wildlife cover, and soil erosion protection. It is adapted for use at Forts Carson, Riley, and Sill, and could be tested in appropriate areas at Fort Bliss.

Establishment: Seeding 1.3 to 2.0 cm deep at rates of 0.5 to 1.0 kg PLS/ha is recommended on well-prepared seedbeds for complex seed mixtures (Gill and Pogge, 1974; Wasser, 1982). Mulching, irrigation, and reduction of grazing and weedy annual competition will improve plant development (Gill and Pogge, 1974; Plummer, et al., 1968; Wasser, 1982). Most seeds will germinate in 30 to 40 days (Milstein and Milstein, 1970), although stratified seeds can germinate in 15 days. Woods rose has good growth and vigor but poor initial establishment. Therefore, containerized plants and root cuttings may improve the stand survival of this species. Seeds can be stored for up to 5 years, and there are 110,000 seeds/kg (Vories, 1981).

Availability/Cultivars: Seeds and transplant materials are readily available commercially, although no cultivars have been developed.

4 SUMMARY

This report has provided a list of grass, forb, and woody plant species suitable for rehabilitating damaged training lands on military installations located in the arid and semi-arid climates of the western United States. For each species, information has been provided on geographic distribution, characteristics, ecological setting, uses, establishment, availability, and cultivars. Long- and short-term revegetation recommendations were prepared for Forts Riley, Sill, Carson, Hood, Bliss, and Irwin.

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APPENDIX A:

PLANTS AND ANIMALS COMMON TO WESTERN INSTALLATIONS
(SCIENTIFIC AND COMMON NAMES)

Plants

Common Name	Scientific Name
Afganistan pine	Pinus brutia
Alfalfa	Medicago sativa
Alkali sacaton	Sporobolus airoides
Allscale	Atriplex polycarpa
Amaranthus	Amaranthus spp.
American elm	Ulmus americana
American pium	Prunus americana
American vetch	Vicia americana
Annual ryegrass	Lolium sp.
Antelope bitterbrush	Purshia glandulosa
Apache plume	Fallugia paradoxa
Arizona fesce	Festuca arizonica
Ashe juniper	Juniperus ashei
Australian saltbush	Atriplex semibacata
Awnless bush sunflower	Helianthus sp.
Bahia grass	Paspalum notatum
Barley	Hordeum vulgare
Basin wildrye	Elymus cinereus
Bearded wheatgrass	Agropyron subsecondum
Beardless wheatgrass	Agropyron inerme
Bermuda grass	Cynodon dactylon
Big bluegrass	Poa ampla
Big bluestem	Andropogon gerardii
Big galleta	Hilaria rigida
Big sacaton	Sporobolus sp.
Big sagebrush	Artemisia tridentata
Birdsfoot trefoil	Lotus corniculatus
Blackbrush	Acacia rigidula
Black grama	Bouteloua eriopoda
Black locust	Robinia pseudo-acacia
Bladderpod	Isomeris arborea
Bluebunch wheatgrass	Agropyron spicatum
Blue grama	Bouteloua gracillis
Bluegrasses	Poa spp.
Blue panic grass	Panicum antidotale
Blue palo verde	Cercidium floridum
Bluestem	Andropogon gerardii
Boer lovegrass	Eragrostis curvula
Brittlebush	Encelia farinosa
Brome grasses	Bromus spp.
Buckwheats	Eriogonum spp.
Buffalograss	Buchloe dactyloides
Buffelgrass	Cenchrus ciliaris
Burrograss	Scleropogon brevifolius

Common Name	Scientific Name
Bush morning glory	Ipomoea leptophylla
Bush muhly	Muhlenbergia Porteri
California buckwheat	Eriogonum fasiculata
California poppy	Eschscholtzia californica
Canada wildrye	Elymus canadensis
Cane bluestem	Andropogon barbinodis
Catclaw acacia	Acacia greggii
Caucasian bluestem	Bothriochloa caucasica
Cedar elm	Ulmus crassifolia
Cheatgrass	Bromus tectorum
Chinkapin oak	Quercus muhlenbergii
Cholla	Opuntia spp.
Cicer milkvetch	Astragalus cicer
Clovers	Trifolium spp.
Cochise lovegrass	Eragrostis trichophora
Common chokecherry	Prunus virginiana
Common yarrow	Achillia millefolium
Coralberry	Symphoricarpos orgiculatus
Creeping barberry	Berberis repens
Creosotebush	Larrea divaricata
Crested wheatgrass	Agropyron cristatum
Crownvetch	Coronilla varia
Curly mesquite	Hilaria belangeri
Desert baileya	Baileya multiradiata
Desert molly	Kochia americana
Desert saltbush	Atriplex desertorum
Desert saltgrass	Distichlis stricta
Desert wheatgrass	Agropyron desertorum
Desert willow	Chilopsis linearsis
Desert zinnia	Zinnia grandiflora
Dogwoods	Cornus spp.
Douglas rabbitbrush	Chrysothamnus viscidiflorus
Dropseeds	Sporobolus spp.
Eastern cottonwood	Populus deltoides
Eastern red cedar	Juniperus virginiana
Elbow bush	Forestiera pubescens
Elms	Ulmus spp.
Engelmann daisy	Engelmannia pinnatifida
Ephedra	Ephedra spp.
Fall witchgrass	Leptoloma cognatum
Filaree	Erodium cicutarium
Flameleaf sumac	Rhus lanceolata
Fleabanes	Erigeron spp.
Fluffgrass	Tridens pulchellus
Fountaingrass	Pennisetum setaceum
Fourwing saltbush	Atriplex canascens
Fringed sagewort	Artemisia frigida
Galleta	Hilaria jamesii
Gambel's oak	Quercus gambelii
German millet	Seteria italica
Golden currant	Ribes aureum
Grama grasses	Bouteloua spp.

Common Name	Scientific Name
Greasewood	Sarcobatus vermiculatus
Greenbrier	Smilax spp.
Green ash	Fraxinus pennsylvanica
Green ephedra	Ephedra viridis
Green needlegrass	Stipa viridula
Green sprangletop	Leptochloa dubia
Hackberry	Celtis occidentalis
Hairy grama	Agropyron hirsuta
Hard fescue	Festuca ovina
Heath aster	Aster eridoides
Honey locust	Gledetsia triacanthus
Illinois bundleflower	Desmanthus illinoensis
Indiangrass	Sargastrum nutans
Indian ricegrass	Oryzopsis hymenoides
Inland saltgrass	Distichlis interior
Intermediate wheatgrass	Agropyron intermedium
Johnson grass	Sorghum halepense
Jojoba	Simmondsia chinensis
Junegrass	Koleria cristata
Junipers	Juniperus spp.
Kentucky bluegrass	Poa pratensis
Kleingrass	Panicum coloratum
Kochia	Kochia americana
Lambsquarter	Chenopodium album
Leadplant amorpha	Amorpha canescens
Lehmann lovegrass	Eragrostis lehmanniana
Lespedezas	Lespedeza spp.
Lewis flax	Linum lewisii
Little bluestem	Schizachyrium scoparium
Littleleaf palo verde	Cercidium microphyllum
Live oak	Quercus virginiana
Lovegrasses	Eragrostis spp.
Lupines	Lupinus spp.
Maximilian sunflower	Helianthus maximiliani
McCartney rose	Rosa bracteata
Meadow brome	Bromus biebersteinii
Mediterranean grass	Schismus barbatus
Mesa dropseed	Sporobolus flexuoss
Mesquite	Prosopis juliflora
Mexican cliffrose	Cowania mexicana
Mexican plum	Prunus mexicana
Millets	Panicum spp.
Mountain brome	Bromus montanum
Mountain mahogany	Cercocarpus montanus
Mountain penstemon	Penstemon montanus
Muhly grasses	Muhlenbergia spp.
Multiflora rose	Rosa multiflora
Mustards	Brassica spp.
Natal redtop	Rhynchelytrum roseum
Needle-and-thread	Stipa comata
New Mexico locust	Robinla neomexicana
Northern sweetvetch	Hedysarum boreale

Common Name	Scientific Name
Oaks	Quercus spp.
Oats	Avena sativa
Oldman saltbush	Atriplex nummularia
Old World bluestems	Andropogon spp.
Orange zexmenia	Zexmenia hispida
Orchardgrass	Dactylis glomerata
Osage orange	Maclura pomifera
Palmer penstemon	Penstemon palmeri
Partridge pea	Cassia nictatans
Pinyon pine	Pinus edulis
Pitcher sage	Salvia pitcheri
Plains bristlegrass	Setaria levcopila
Plains lovegrass	Eragrostis intermedia
Prairie coneflower	Ratibida sp.
Prairie junegrass	Koleria cristata
Prairie sandreed	Calamovilfa longifolia
Prickly pear	Opuntia spp.
Prostrate summer cypress	Kochia prostrata
Pubescent wheatgrass	Agropyron trichophorum
Purple prairieflower	Petalostemum purpureum
Possumhaw	Ilex decidua
Quailbush	Atriplex lentiformis
Ragweed	Ambrosia psilostachya
Red brome	Bromus rubens
Redroot pigweed	Ceanothus americanus
Redtop	Agrostis alba
Reed canarygrass	Phalaris arundinacea
Rice	Oryiza sativa
Roses	Rosa spp.
Rough mendora	Menodora scabra
Roundhead lespedeza	Lespedeza capitata
Rubber rabbitbrush	Chrysothamnus nauseosus
Ruby sheepbush	Enchylaena tomentosa
Russian olive	Elaeagnus angustifolia
Russian thistle	Salsola kali
Russian wildrye	Elymus junceus
Rye	Secale cereale
Sagewort	Artemisia nova
Sainfoin	Psoralioides onobrychis
Saltbushes	Atriplex spp.
Sandberg bluegrass	Poa secunda
Sand bluestem	Andropogon hallii
Sand dropseed	Sporobolus cryptandrus
Sand lovegrass	Eragrostis trichoides
Scarlet globemallow	Sphaerlacea coccinea
Serviceberry	Amelanchier spp.
Shadscale	Atriplex confertifolia
Showy mendora	Mendora longiflora
Shrubby buckwheat	Eriogonum fasiculatum
Siberian peashrub	Caragana arborescens
Siberian wheatgrass	Agropyron sibericum
Sideoats grama	Bouteloua curtipendula

Common Name	Scientific Name
Silver buffaloberry	Shepherdia argentea
Skunkbush sumac	Rhus trilobata
Slender gaillardia	Gaillardia pinnatifida
Slender wheatgrass	Agropyron trachycaulum
Smooth brome grass	Bromus inermis
Sorghum	Sorghum vulgare
Southwest rabbitbrush	Chrysothamnus sp.
Sphaeralcea	Sphaeralcea sp.
Spike dropseed	MuhlenbeChrysothamnus sp.
Spike muhly	Grayia sprgia wrightii
Spiny hopsage	Helianthusinosa
Stiff sunflower	Helianthus laetiflorus
Streambank wheatgrass	Agropyron riparium
Sudangrass	Sorghum sudanense
Sumacs	Rhus spp.
Sunflowers	Helianthus spp.
Sweetclover	Melilotus officinalis
Switchgrass	Panicum virgatum
Tall fescue	Festuca arundinacea
Tall wheatgrass	Agropyron elongatum
Tarbush	Flourensis cernua
Texas ash	Fraxinus texensis
Texas oak	Quercus texana
Texas panic grass	Panicum texanum
Texas persimmon	Diospyros texana
Thatchgrass	Hyparrhenia hirta
Thickspike wheatgrass	Agropyron dasystachyum
Three-awn grass	Fristida oligantha
Thurber fescue	Festuca thurberi
Timothy	Phleum pratense
Tobossa	Hilaria mutica
Triangleleaf bursage	Franseria deltoides
True mountain mahogany	Cercocarpus montanus
Two-flower trichloris	Trichloris crinita
Upright prairie coneflower	Ratibida columnaris
Vetch	Vicia spp.
Vine mesquite	Panicum obtusum
Weeping lovegrass	Eragrostis curvula
Western indigo	Amorpha sp.
Western snowberry	Symphoricarpos occidentalis
Western virginbower	Clematis ligusticifolia
Western wheatgrass	Agropyron smithii
Wheat	Triticum aestivum
White brittlebush	Encelia farinosa
White bursage	Franseria dumosa
White clover	Trifolium repens
Whitethorn acacia	Acacia constricta
Wilman lovegrass	Eragrostis superba
Winterfat	Ceratoides lanata
Winter wheat	Triticum aestivum
Yellow bluestem	Andropogon sp.
Yellow Indiangrass	Sorgastrum nutans

Common Name	Scientific Name
Yellow sweetclover	Melilotus officinalis
Yucca	Yucca spp.

Animals

Common Name	Scientific Name
Cattle	Bos taurus
Desert bighorn sheep	Ovis canadensis
Mule deer	Odecoileus hemionus
Rocky Mountain elk	Cervus canadensis nelsoni
Sheep	Ovis aries
Whitetailed deer	Odecoileus virginianus

APPENDIX B:

SEED AND NURSERY STOCK SOURCES IN THE WESTERN UNITED STATES

ARIZONA

ABC Seed Company
343 E. Broadmor Dr.
Tempe, AZ 85282

Advance Seed Company
310 S. 24th Ave.
Phoenix, AZ 85008

Apache Coat Seed Company
1412 E. Pierce St.
Phoenix, AZ 85006

Arizona Cypress Gardens
Star Route 2
Sedona, AZ 86336

Arizona Range Grass Seed Company
Route 1, Box 850
Wilcox, AZ 85643

Arizona Soil Conservation Service
Plant Materials Center
241 Romero Rd.
Tucson, AZ 85705

Camelot Nurseries, Inc.
6030 Mockingbird Lane
Scottsdale, AZ 85251

Catalina Heights Nursery
6047 E. Pima
Tucson, AZ 85716

Christa's Cactus
529 W. Pima
Coolidge, AZ 85228

Desert Enterprises
P.O. Box 23
Morristown, AZ 85342

Desert Plants
2735 E. Camelback
Phoenix, AZ 85016

Desert Tree Farms
20039 N. Cave Creek Rd.
Phoenix, AZ 85024

Emac Seed Company
Box 338
Wilcox, AZ 85643

Ferry-Morse Seed Company
310 S. 24th Ave.
Phoenix, AZ 85005

Mrs. Dorothy Fultz
611 W. Vine Ave.
Mesa, AZ 85201

Germain's Inc.
Box 1347
Glendale, AZ 85301

Greenland Nursery
7909 E. 22nd St.
Tucson, AZ 85710

Harlow Nursery
5620 E. Pima
Tucson, AZ 85716

Harper's Nursery
1830 E. McKellips Rd.
Mesa, AZ 85201

Hubbs Bros. Seed Company
1015 N. 35th St.
Phoenix, AZ 85008

Liefgreen Seed Company
Glendale, AZ 85301

Mountain States Wholesale Nursery
P.O. Box 33982
Phoenix, AZ 85067

Northrup-King and Company
Box 6069
Phoenix, AZ 85005

Perry's Plants, Inc.
3221 E. Baseline
Phoenix, AZ 85054

Powerhorn Nursery
10100 E. Cactus Rd.
Scottsdale, AZ 85257

Silverbell Nursery
2730 N. Silverbell Rd.
Tucson, AZ 85705

Sonoran Desert Nurseries
2923 S. 115th Way
Chandler, AZ 85224

Sonora Nursery
P.O. Box 2197
Glendale, AZ 85311

Southwestern Native Seeds
P.O. Box 50503
Tucson, AZ 85703

Tanque Verde Nursery
Route 2, Box 774 P
Tucson, AZ 85715

Bill Thornton
1619 E. 8th
Tucson, AZ 85719

Tip Toe Nurseries
2941 N. 43rd Ave.
Phoenix, AZ 85031

Valley Seed Company, Inc.
P.O. Box 1110
Phoenix, AZ 85001

CALIFORNIA

ABC Nursery, Inc.
424 East Garden Boulevard
Gardena, CA 90248

Albright & Towne, Inc.
1320 Galaxy Wy. "G"
Concord, CA 94520

A. L. Castle
27 North Wilson Way
Stockton, CA 95205

Agri-Turf Supplies, Inc.
Box 4191
Santa Barbara, CA 93103

Alco Chemical Company
19220 Pioneer Boulevard
Artesia, CA 90701

Arnold-Thomas Seed Service
Box 2345
Fresno, CA 93723

Avalon Gardens, Inc.
13007 East Telegraph Road
Santa Fe Springs, CA 90670

Beagle Products Company
Box 874
West Sacramento, CA 95691

Bemis Company
1255 Post Street
San Francisco, CA 94109

Berger and Plate Company
One California Street
San Francisco, CA 94104

Bibens Nursery Company
6131 Hammett Road
Modesto, CA 95351

Blue Oak Nursery
2731 Mountain Oak Lane
Rescue, CA 95672

Bodger Seeds Limited
1800 Tyler Avenue
Box 5090
South El Monte, CA 91734

Bordiers Nursery, Inc.
7231 Irvine Boulevard
Santa Ana, CA 92705

Burton's Oak Grove Nursery
1190 Oak Grove Road
Walnut Creek, CA 94598

Butler's Mill, Inc.
5180 Naranja Street
San Diego, CA 92114

Cagwin and Dorward
1637 Francisco Boulevard
San Rafael, CA 93901

Calaveras Nursery
1622 Highway 12
Valley Springs, CA 95252

California Liquid Fertilizer Company
755 South Raymond Avenue
Pasadena, CA 91105

California Nursery Company
P.O. Box 2278
Fremont, CA 94536

Cal-Kirk Landscape Contractors
1127 Bayside Road
Arcata, CA 95521

Cardiff Associates, Inc.
4607 Camden Drive
Corona Del Mar, CA 92625

Carter's Seeds
475 Mar Vista Drive
Vista, CA 92083

Casper's "Snow-Kist" Evergreen Trees
1809 Chester Avenue
Bakersfield, CA 93302

Central Nursery Company
2675 Johnson Avenue
San Luis Obispo, CA 93402

Christensen's Nursery
935 Old County Road
Belmont, CA 94002

Richard Clinebell
59 Vicksburg Street
San Francisco, CA 94114

Clotilde Merlo Nursery
Louisiana-Pacific Corporation
Trinidad, CA 95570

Clyde Robin Seed Company, Inc.
Box 2855
Castro Valley, CA 94546
(415) 581-3467

D. W. Woodruff
Sonora, CA 95370

Dale Dunlop Seed Company
950 Williams Street
Williams, CA 95987

Deigaard Nursery, Inc.
1339 East Huntington Drive
Duarte, CA 91010

Deigaard Nurseries, Inc.
Box 582
Monrovia, CA 91017

Deigaard Nurseries, Inc.
5295 Shoreline Drive
Santa Barbara, CA 93105

Desert Seed Company, Inc.
Box 181
El Centro, CA 92243

East Slope Tree Farm
Sunnyside Road
Janesville, CA 96114

Eltis-Wilbur Company
696 Naples Street
Chula Vista, CA 92011

Environmental Seed Producers, Inc.
P.O. Box 5904
El Monte, CA 91734

Ferry Morse Company
Box 1081
Modesto, CA 95352

Ferry Morse Seed Company
2120 Via Burton
Anaheim, CA 92806

Ferry-Morse Seed Company
Box 967
Mountain View, CA 94040

Floyd L. Offer
15 Dayton Avenue
Fresno, CA 93705

Forest Seeds of California
Box 651
Davis, CA 95616

Forest Tree Seed
Box 100
Magalia, CA 95954

Fowler Nurseries, Inc.
525 Fowler Road
Newcastle, CA 95658

Frazier Nursery
3537 Mount Pinos Way
Frazier Park, CA 93225

Germains, Inc.
4820 East Fiftieth Street
Los Angeles, CA 90058

Germains, Inc.
Box 1985
Jensen and Chestnut Streets
Fresno, CA 93718

Glass Mountain Tree Farm and Nursery
Box 440
Saint Helena, CA 94574

Greener'n Ever Tree Farm and Nursery
P.O. Box 222435
Carmel, CA 93922

Hardscrabble Seed Company
Route 2, Box 255
Springville, CA 93265

H-H Forest Tree Nursery, Inc.
Box 427
Sebastopol, CA 95472

Herman L. Suter
Suter Nursery
3220 Silverado Trail North
Saint Helena, CA 94574

Industrial Rehabilitation Service, Inc.
2043 South Imperial Street
Los Angeles, CA 90021

J. Harold Mitchell Company
305 Agostino Road
San Gabriel, CA 91776

Johnson's Cactus Gardens
Paramount, CA 90723

Koda Brothers Rice Mills
South Dos Palos, CA 93665

Laguna Selva Christmas Trees
2000 Laguna Road
Santa Rosa, CA 95401

Larner Seeds
P. O. Box 11143
Palo Alto, CA 94306

Lockeford Plant Materials Center
P.O. Box 68
Lockeford, CA 95237

Las Vegas Fertilizer and Seed Company
26035 East Baseline
San Bernardino, CA 92410

Leonard Coates Nursery, Inc.
San Jose, CA 95114

Manning's Heather Farm
12450 Fiori Lane
Sebastopol, CA 95472

Mayflower Nurseries, Inc.
16908 South Normandie Avenue
Gardena, CA 90247

Mistletoe Sales
247 West Alamar
Santa Barbara, CA 93105

Monrovia Nursery Company
Box Q
18331 East Foothill Boulevard
Azusa, CA 91702

Moulder Brothers Landscape Contractors
511 Western Avenue
Glendale, CA 91201

Naka Nursery
40735 Mission Boulevard
Fremont, CA 94536

Joe Manning Seeds, Inc.
Box 1092
Sun Valley, CA 91352

Nature-Gro Corporation
28272 Dorothy Drive
Box 374
Agoura, CA 91301

Northrup-King and Company
Box 1383
Fresno, CA 92716

Northrup-King and Company
5680 Sheila Street
Los Angeles, CA 90040

O. Kenneth Smith
Skyway
Box 100
Magalia, CA 95954

O. M. Scott and Sons Company
Box 2079
Oakland, CA 94604

Occidental Chemical Company
Box 638
Azusa, CA 91702

Oki Nursery, Inc.
Box 7118
Sacramento, CA 95826

Olgiate and Kurtz
1610 Old Bayshore Highway
San Jose, CA 95112

Pacific Tree Farms
4301 Lynnwood Drive
Chula Vista, CA 92010

Pecoff Brothers Nursery and Seed, Inc.
5, Box 215R
Escondido, CA 92025

Perry's Plant, Inc.
19362 Walnut Drive
La Puente, CA 91748

Plant Gro Corporation
Box 703
San Jose, CA 95106

Native Plant Farm
3350 Saint Helena Highway, North
Saint Helena, CA 94574

Ramsey Seed, Inc.
Box 352
Manteca, CA 95336

Redwood City Seed Company
P.O. Box 361
Redwood City, CA 94064

Robinson Fertilizer Company
119 North Olive Street
Organe, CA 92666

Roy Carter
Box 4006
14363 Bledsoe Street
San Fernando, CA 91342

S and S Seeds
382 Arboleda Road
Santa Barbara, CA 93110

Sacramento Im-pruv-all
3705 El Centro Road
Sacramento, CA 95834

Sacramento Valley Milling Company
P.O. Box 68
Ord Bend, CA 95943

Saratoga Horticultural Foundation
20605 Verde Vista Lane
Box 308
Saratoga, CA 95070

Security Seed Company
247 West Alamar
San Joaquin, CA 93105

Selby's Soil Erosion Control Route
Company
Kilkenny Road
Route 2, Box 1170
Vacaville, CA 95688

Select Nurseries, Inc.
12831 East Central
Brea, CA 95070

Sequoia Forest Products Company
Box 305
Dinuba, CA 93618

C. L. Putnam-Tree Grower
32300 Annapolis Road
Annapolis, CA 95412

Shop in the Sierra
Box 1
Midpines, CA 95345

Skylark Wholesale Nursery
6785 Sonoma Highway
Santa Rosa, CA 95404

Smith and Reynolds Erosion Control
206 North Smith Road
Corona, CA 91720

Southern California Seed Company
964 South San Pedro
Los Angeles, CA 90015

Spanish Canyon Tree Farm
2550 Oak Court Road
Ukiah, CA 95482

Sta-Soil Corporation
5275 Craner Avenue
North Hollywood, CA 91601

Stover Seed Company
1415 E. 6th St.
Los Angeles, CA 90021

Talsco Chemical and Equipment Company
12655 East Imperial Highway
Santa Fe Springs, CA 90670

Taylor Nursery
547 Carpenteria Road
Box 214
Aromas, CA 95004

The Theodore Payne Foundation
for Wild Flowers and Native
Plants, Inc.
10459 Tuxford Street
Sun Valley, CA 91352

Tom W. Williams
2915 Old Gravenstein Highway
Box 535
South Sebastopol, CA 95472

Trees & Earthworks Nursery
P.O. Box 17
Casper, CA 95420

Valley Wide Chemical Company
P.O. Box 926
Gridley, CA 95948

Wapumne Native Plant
Company
8305 Cedar Crest Way
Sacramento, CA 95826

Watlee Burpee Company
Box 748
Riverside, CA 92502

Western Forestry
Box 422
San Jose, CA 94103

Western Timber Services, Inc.
Box 603
Arcata. CA 95521

Wilbur-Ellis Company
970 Goodrich Boulevard
Los Angeles, CA 90022

Yerba Buena Nursery
19500 Skyline Boulevard
Woodside, CA 94062

COLORADO

Anderson Seed and Grain, Inc.
Lamar, CO 81052

Anderson Seed
2410 10th Street
Greely, CO 80631

Applewood Nursery and Seed Company
15001 West Thirty-second Avenue
Route 3, Box 84
Golden, CO 80401

Arkansas Valley Seeds, Inc.
P.O. Box 270
Rocky Ford, CO 81067

Carhart Feed & Seed
P.O. Box 55, Third & Guyman
Dove Creek, CO 81324

Col-Hydro, Inc.
5555 Ute Highway
Longmont, CO 80501

Dean Swift
Box 24
Jaroso, CO 81138

Environmental Landscapes, Inc.
2442 West Evans Avenue
Denver, CO 80202

Environmental Plant Center
P.O. Box 448
Meeker, CO 81641

Farmers Marketing Association
4545 Madison Street
Denver, CO 80216

George Kelly
McElmo Creek Route
Cortez, CO 81321

Hydro-Gardens, Inc.
P.O. Box 9707
Colorado Springs, CO 80932

Iliff Gardens
4750 East Iliff Avenue
Denver, CO 80222

Kroh Nursery
Loveland, CO 80537

Mile High Seed Company
Box 1988
Grand Junction, CO 81501

Neco, Inc.
Box 1178
Cahone, CO 81320

Northrup-King and Company
1621 West Twelth Avenue
Denver, CO 80204

Northrup King and Company
Box 998
Longmont, CO 80501

San Juan Native Nursery
Box 302
Pagosa Springs, CO 89117

Steamboat Landscaping, Inc.
Box 1521
Steamboat Springs, CO 80477

Timberline Tree Seed
Rye Star Route, Box 145
Pueblo, CO 81004

Treehouse Nursery
7450 Valmont Road
Boulder, CO 80301

Virginia L. Stephenson
Box 296
Colorado Springs, CO 89099

Western Evergreen, Inc.
14201 West Forty-fourth Avenue
Golden, CO 80401

Yellow Pine Nurseries
Box 192
Kiowa, CO 80117

IDAHO

Aberdeen Plant Materials Center
P.O. Box AA
Aberdeen, ID 83210

Brown King Nursery
1407 Arthur Street
Caldwell, ID 83605

C. A. Wheeler
4100 Palouse Street
Boise, ID 83705

C. J. Russell
Box 217
Glenns Ferry, ID 83623

Canyonside Nursery
Route 3
Twin Falls, ID 83301

Charles Larson
Worley, ID 83876

Christman and Hopkins
Soda Springs, ID 83276

Clifty View Nursery
Route 1, Box 509
Bonners Ferry, ID 83805

Cloverdale Nursery
2526 North Cloverdale Road
Boise, ID 83702

Dahlin's Nursery
Route 1, Box 304
Priest River, ID 83856

Dale Lyons
Grand View, ID 83624

Dandelion Enterprises
3416 Tamarack Drive
Boise, ID 83703

Delbert F. Winterfield
Box 97
Swan Valley, ID 83449

Don Bell
237 South Fourth Street
Pocatello, ID 83201

Ed Griffith
Route 2
Caldwell, ID 83605

Fantasy Farm Nursery
Box 157
Peck, ID 83545

L. E. Ford Seeds
2918 Woody Drive
Boise, ID 83703

Garden Square
Lewiston, ID 83501

George Hedlind
Route 3
Rupert, ID 83350

George Lemon
Hagerman, ID 83332

Globe Seed & Feed Company, Inc.
Box 445
Twin Falls, ID 83301

Gooding Seed Company
Box 57
Gooding, ID 83330

Grassland West Company
P.O. Box A
Culdesac, ID 83524

Harold L. Harris
Box 415
Aberdeen, ID 83210

Hillside Nursery
2350 Hill Road
Boise, ID 83702

Idaho Grimm Growers
Warehouse Corp.
P.O. Box 276
Blackfoot, ID 83221

Jacklin Seed Company
W. 5300 Jacklin Avenue
Post Falls, ID 83854

John Kaylor
Lenore, ID 83541

Kenneth Ford
Beaver Enterprises
3416 Tamarack Drive
Boise, ID 83704

Kimberly Nurseries
Addison Avenue East
Twin Falls, ID 83301

Larry Reynolds
Box 56
Moore, ID 83255

Levig Nursery
Star Route 1, Box 22
Bonners Ferry, ID 83805

Maurice Guerry, Jr.
Buhl, ID 83316

Neil J. Poulson
American Falls, ID 83211

Northplan Seed Producers
N.A.P.G., Inc.
P.O. Box 9107
Moscow, ID 83843

Northrup-King and Company
Box 7746
Boise, ID 83703

Northrup-King and Company
Box 124
Twin Falls, ID 83301

Philip Jardine
Route 4, Box 315
Idaho Falls, ID 83401

Ray F. Blair
Box 813
Glenns Ferry, ID 83623

Ross Telford
Preston, ID 83253

The Rudy-Patrick Company
Box 1130
Nampa, ID 83651

Simmons and Johnson
Box 168
Iona, ID 83427

Simplot Soilbuilders
Box 342
Meridian, ID 83642

The Silva Star Company, Inc.
Route 1, Box 64-A
Potlatch, ID 83855

Smith Tree Plantation
Route 1, Box 129, Iona N. Rd.
Idaho Falls, ID 83401

US Forest Service Experiment Nursery
Route 1, Alene Box 245
Coeur d'Alene, ID 83814

Union Seed Company
P.O. Box 339
Nampa, ID 83651

W. R. Grace Company
Box 999
Nampa, ID 83651

Winterfeld Ranch Seed Company
P.O. Box 97
Swan Valley, ID 83449

KANSAS

Buskirk Horticultural Service
1621 East Kansas Avenue
Mcpherson, KS 67460

Manhattan Plant Materials Center
Route 2, Box 314
Manhattan, KS 66502

Sharp Bros. Seed Company
Healy, KS 67850

Skinner Company Nursery
P.O. Box 8068
Topeka, KS 66608

Sommer Brothers Seed Comapny
Box 19021
Topeka, KS 66619

Willis Nursery Company, Inc.
P.O. Box 530
Ottawa, KS 66067

MONTANA

A. L. Bruce Seed Company
Townsend, MT 59664

Adsit Farm and Ranch Service
Decker, MT 59025

Alpin Nursery
1763 Highway 2 East
Kalispell, MT 59901

Art Christensen
Box 186
Dillon, MT 59725

Arthur DeGrand
Baker, MT 59313

Ben Lund
Big Sandy, MT 59520

Bennie Gevig
Plevna, MT 59334

Bitter Root Nursery
Corvallis, MT 59828

Boyd Crawford
Fort Benton, MT 59442

Bridger Plant Materials Center
Route 1, Box 119
Bridger, MT 59014

Buffalo Bill Nursery
Route 2, Box 66
Plains, MT 59859

Canyon Creek Nursery
West
Billings, MT 59101

Cenex Seed Company
Box 1748
Billlings, MT 59103

Clear Creek Hereford Ranch
Chinook, MT 59523

David A. Lawyer Nursery
Plains, MT 59859

E. C. Moran
Box 327
Stanford, MT 59479

Eisenman Seed Company
Fairfield, MT 59436

F. B. Arnett
Columbia Falls, MT 59072

Frank Rose
1020 Poplar Street
Missoula, MT 59801

Gerald H. Tohman
Route 2
Geraldine, MT 59446

Gilbert Ehli
Sweetgrass, MT 59484

Hayden Porter
Decker, MT 59025

Hi-Mountain Farm
Route 1, Box 29
Seligman, MT 65745

James Crandall
Scobey, MT 59263

Joe Lincoln
Valier, MT 59486

K and K Seed Comany
Route 3
Conrad, MT 59425

Ken Clouter
Btusett, MT 59318

Mannakee Seed Company
Box 68
Cascade, MT 59421

Marchie's Nursery
1845 South Third West
Missoula, MT 59801

Mart Crestsinger
Baker, MT 59313

Montana Seeds, Inc.
Route 3
Conrad, MT 59425

Mountain Home Nurseries
Box 26
Deborgia, MT 59830

Nathan Manakee
Cascade, MT 59421

Northrup-King and Company
Box 389
Billings, MT 59103

Powder River Seed Company
Box 673
Broadus, MT 59317

Quality Seed Company
P.O. Box 31
Lewistown, MT 59457

R. M. Gregor Landscaping
1310 Greene Street
Helena, MT 59601

Renn's Blue Spruce Nursery
6305 Highway 2 East
Columbia Falls, MT 59912

Robert Hungate
Stanford, MT 59479

Snow Line Tree Company, Inc.
Highway 93 South
Kalispell, MT 59901

State Nursery Company
West
Helena, MT 59601

Thomas F. Burns
Chinook, MT 59523

Tom Adsit
Decker, MT 59025

Valley Nursery
Box 4845
Helena, MT 59601

Wanner Nursery
Corvallis, MT 59828

Wesley Adolph
Roundup, MT 59072

Western Seed and Supply, Inc.
Box 57
Charlo, MT 59824

William Skorupa
Bridger, MT 59014

NEBRASKA

Arrow Seed Company, Inc.
Box 722
Broken Bow, NE 68822

Cenex Seed Company
Box 1061
Grand Island, NE 68801

Flatlandscapes
1219 16th Street
Aurora, NE 68818

Horizon Seeds, Inc.
P.O. Box 81823
1600 Cornhusker Highway
Lincoln, NE 68501

Marshall Nurseries
205 North 2nd
Arlington, NE 68003

Miller Seed Company
Box 81823
Lincoln, NE 68501

Miller Seed Company
1540 Cornhusker Highway
Lincoln, NE 68501

Plumfield Nurseries, Inc.
210 North Nye Street
Box 410
Fremont, NE 68025

Stock Seed Farms, Inc.
Route 1, Box 112
Murdock, NE 68407

Mrs. Adolph Travnice
Route 1
Cedar Bluffs, NE 68015

Trojan Seed Company
Route 2
Lyman, NE 69352

Willow Creek Nursery
R. R. 1, P.O. Box 485
Chappell, NE 69129

Wilson Seed Farms
Route 1, Box 7
Polk, NE 68654

NEW MEXICO

Catiflor
Box 787
Balew, NM 87002

Curtis & Curtis Seed and Supply
Star Route, Box 8A
Clovis, NM 88101

Charlie Devoe
P.O. Box 330 Route 3
Las Lunas, NM 87031

C. H. Diebold
Box 483, RFD 3
Los Lunas, NM 87031

Dan Cristo
New Mexico Native Plant Nursery
of S.W.SH.
309 West College Avenue
Silver City, NM 88061

Grasslands Resources, Inc.
Santa Fe, NM 87501

Jose Montano, Director
Mora Research Center
Box 357
Mora, NM 87732

Leslie Clayshulte
Agricultural Seed Company
Drawer A
Mesquite, NM 88048

Los Lunas Plant Materials Center
1036 Miller St., S.W.
Los Lunas, NM 87031

Malone Farms, Ltd.
Route 1, Box 76
Lake Arthur, NM 88253

Mountain States Chemical Company, Inc.
316 Industrial, Northeast
Albuquerque, NM 87107

Mountain Valley Nursery
Box 81
Lincoln, NM 88338

New Mexico Cactus Research
P.O. Box 787
Belen, NM 87002

New Mexico Native Plant Nursery
309 West College
Silver City, NM 88061

Plants of the Southwest
1570 Pacheco Street
Santa Fe, NM 87501

Sam Donaldson
70 San Juan
Los Alamos, NM 87544

Wildland & Native Seeds Foundation
2402 Hoffman Drive NE
Albuquerque, NM 87110

NEVADA

Clinton Sidwell
Battle Mountain, NV 89820

Dan Aten
Battle Mountain, NV 89820

S. S. Lawrence
Box 405
Las Vegas, NV 89100

NORTH DAKOTA

Bismarck Plant Materials Center
Lincoln-Oakes Nursery
P.O. Box 1458
Bismarck, ND 58501

Cenex Seed Company
P.O. Box 155
Williston, ND 58801

Fey's Nursery and Seed Company
Sheldon, ND 58068

Forestry Seed Market
Box 156
Sheldon, ND 58068

Interstate Seed and Grain Company
Box 470
Fargo, ND 58102

Lincoln-Oakes Nurseries
Box 1601
Bismarck, ND 58501

State Forest Nursery
Bottineau, ND 58318

Towner Nursery
Towner, ND 58788

OKLAHOMA

Howard Adams
Fargo, OK 73840

John Bowzar
Fargo, OK 73840

Coury Enterprises
2828 Northwest 57th
Oklahoma City, OK 73112

Eckroat Seed Company, Inc.
P.O. Box 17610
Oklahoma City, OK 73136

The Great American Seed Company
P.O. Box 725
Hennessey, OK 73742

Greenleaf Nursery Company
Route 1, Box 163
Park Hill, OK 74451

Chuck Grimes
RFD
Hennessey, OK 73742

Honey Creek Nursery
Route 4, Box 514
Grove, OK 74344

Johnston Seed Company
Box 1392
Enid, OK 73701

Marley Seed Company
Box 589
Vinita, OK 74301

Melot's, Inc.
P.O. Box 154
Bethany, OK 73008

Mid-Western Nurseries, Inc.
P.O. Box 768
Tahlequah, OK 74464

Tom Munger Seed Company
Box 975
Enid, OK 73701

Oklahoma Department of Agriculture
Forestry
Division Nursery
Route 1, Box 44
Washington, OK 73093

Spears Tree Farm
Route 1, Box 138
Tahlequah, OK 74464

Twam Nurseries, Inc.
Route 1
Pauls Valley, OK 73075

Valley View Nursery
Route 1, P.O. Box 400
Parkhill, OK 74451

Weyerhaeuser Company
Route 1, Box 10A
Fort Townson, OK 74735

OREGON

Browning's Nursery
P.O. Box 243
Sixes, OR 97476

C. C. Garrison
103 Southeast Third Avenue
Milton-Freewater, OR 97862

Conifer Seed Company
5182 Sunnyside Road
Salem, OR 97302

Corvallis Plant Materials Center
3240 N.W. Granger Avenue
Corvallis, OR 97330

D. W. Stryker
Rare Plant Garden
Langlois, OR 97450

D. V. Mallery
1506 Northeast Northview
Bend, OR 97701

Dan Cronin
449 South Diamond
Burns, OR 97720

David Malpaus
Route 1, Box 142
Harrisburg, OR 97446

Dean Creek Nursery, Inc.
Route 4, Box 16F
Reedspot, OR 97467

Donald Hector
Route 1, Box 390
Corvallis, OR 97330

Doty and Doerner, Inc.
6691 Southwest Capital Highway
Portland, OR 97219

Drake's Crossing Nursery
19774 Grade Road S.E.
Silverton, OR 97381

Ferris Nursery
Box 402
South Beach, OR 97366

Ferris Quality Nursery
Thiel Creek Road
Star Route, South Beach
Newport, OR 97366

Forest Farm
990 Tetherow Road
Williams, OR 97544

Forest Seedlings, Inc.
P.O. Box 430
Brownsville, OR 97327

Garrison Seed Company
103 S.E. Third Avenue
Milton-Freewater, OR 97862

Giffen's Greens
295 East Main Street #1
Ashland, OR 97520

Russell Graham
4030 Eagle Crest Road N.W.
Salem, OR 97304

Great Western Seed Company
P.O. Box 387
Albany, OR 97321

Greer Gardens
1280 Goodpasture Island Road
Eugene, OR 97401

Kintigh's Mountain Home Ranch
38865 East Cedar Flat Road
Springfield, OR 97477

Lava Nursery, Inc.
P.O. Box 370
Parkdale, OR 97041

Lindstrom's Nursery
Hamlet Route, Box 950
Seaside, OR 97138

McDaniel Nursery
2494 Robin Lane
Central Point, OR 97502

McFarland Trading Company
Box 68
Hubbard, OR 97032

Milton Nursery Company
Box 7
Milton-Freewater, OR 97862

Nature's Garden
Route 1, Box 488
Beaverton, OR 97007

Normarc, Inc.
Box 238
Tangent, OR 97389

North Coast Seed Company
P.O. Box 12185
Portland, OR 97212

Northwest Native Growers
Route 2, Box 87
Clackamas, OR 97015

Northwest Biological Enterprises
23351 S.W. Bosky Dell Lane
West Linn, OR 97068

Oakhill Gardens
1960 Cherry Knoll Road
Dallas, OR 97338

Oregon Native Nursery
Route 2, Box 114
Canby, OR 97013

Oregon Natives
Route 1, Box 7
Woodburn, OR 97071

Pacific Coast Nursery, Inc.
Route 1, Box 320
Portland, OR 97501

Pacific Forest Seeds
Box 1363
Medford, OR 97501

Pahachneider Brothers
Route 1, Box 398
Woodburn, OR 97071

Reforestation Services, Inc.
Box 3291
Salem, OR 97302

Richard A. Oja
Route 4, Box 265
Astoria, OR 97502

Frank T. Sesock, Seedsman
6045 Foley Lane
Central Point, OR 97502

Sherwood Nursery Company
13020 Northeast Rose Parkway
Portland, OR 97320

Silver Falls Nursery
Star Route, Box 55
Silveton, OR 97391

Simonet Forestry
19440 S.W. Anderson Street
Aloha, OR 97007

Simpson Timber Company
P.O. Box 308
Albany, OR 97321

Siskiyou Rare Plant Nursery
2825 Cummings Road
Medford, OR 97501

Sky-Cleft Gardens
Camp Street Extension
Medford, OR 97501

H. J. Stoll and Sons, Inc.
2320 Southeast Grand Avenue
Portland, OR 97214

Turner Regeneration Center
Weyerhaeuser Company
16014 Pletzer Road, S.E.
Turner, OR 97392

Ted Hanson
2832 Redgeway Drive
Reedsport, OR 97467

Willamette Seed and Grain Company
Box 791
Albany, OR 97321

Woodsman Native Nursery
Route 1, Box 280
Florence, OR 97439

SOUTH DAKOTA

Arvid Mahalan
Sturgis, SD 57785

CENEX Seed Plant
Box 964
Sioux Falls, SD 57101

Clark Dale Nursery
Milbank, SD 57252

Clarkdale Nursery
kural Route 1
Twin Brooks, SD 57269

Clyde Barr
Prairie Gem Ranch
Smithwick, SD 57782

Farmers Feed and Seed Company, Inc.
Box 520
Sturgis, SD 57785

Gurney Seed and Nursery Company
Second and Capital
Yankton, SD 57078

Hansmeier and Sons, Inc.
Bristol, SD 57219

Merl Gunderson Nursery
Rapid City, SD 57701

Robert D. Larson
Alzada Route
Belle Fourche, SD 57717

Rethke Nursery
P.O. Box 82
Milbank, SD 57252

The Sexauer Company
P.O. Box 58
Brookings, SD 57006

TEXAS

Alexander Seeds
Star Route A, Box 1110
Austin, TX 78700

W. H. Anton Seed Company, Inc.
Box 667
Lockhart, TX 78644

Asgrow Seed Company
P.O. Drawer A
San Antonio, TX 78211

Austin Tree Farm, Inc.
1935 Berkely
Austin, TX 78745

Greenhills Foundation
7575 Wheatland Road
Dallas, TX 75249

Bamert Seed Company
Route 3, Box 192
Muleshoe, TX 79347

Bright Forest Nursery
Route 3, Box 428
Quinlan, TX 75474

Carroll Abbott's Green Horizons
500 Thompson Drive
Kerrville, TX 78028

Conlee Seed Company
P.O. Box 267
Waco, TX 76228

Dallas Nurseries, Inc.
12501 Preston Rd.
Dallas, TX 75230

Empire Seed Company
109 East Ave. A
Temple, TX 76501

Foster-Rambie Grass Seed
326 North Second Street
Uvalde, TX 73801

Benny J. Gallagar
P.O. Box 10254
Corpus Christi, TX 78410

O. F. Garrett
Box 817
Ysleta, TX 79917

Garrison Seed Company, Inc.
East Highway 60, P.O. Box 927
Hereford, TX 79045

Tom Goodell
Route 2, Box 376
Eustace, TX 75124

Green Horizons
500 Thompson Dr.
Kerrville, TX 78028

Green Valley Nurseries, Inc.
P.O. Box 548
Floresville, TX 78114

Rudy-Patrick Seed Company
Box 218
Garland, TX 75040

Harpool Seed, Inc.
P.O. Drawer B
Denton, TX 76201

Harris Nursery
Route 1, Box 41
Plains, TX 79355

Hawkins Nursery & Landscape Company
P.O. Box 298
Grand Saline, TX 75140

Horizon Seeds, Inc.
Box 886
Hereford, TX 79045

Douglass W. King Company, Inc.
P.O. Box 29320
San Antonio, TX 78286

Knox City Plant Material Center
Route 1, Box 155
Knox City, TX 79529

Lowrey Nursery
2323 Sleepy Hollow Road
Conroe, TX 77302

McVicar Organic Nursery
2170 South St.
Nacogdoches, TX 75961

Miller Seed Company
Box 886
Hereford, TX 79045

Native Son Plant Nursery
507 Lockhart Drive
Austin, TX 78704

G. E. Pohne Seed Company, Inc.
Drawer 389
Kenedy, TX 78119

Ribinson Seed Company
1113 Jefferson
Plainview, TX 79072

Sharp Brothers Seed Company
4378 Canyon Drive
Amarillo, TX 79109

Star Seed & Grain Corporation
415 Blue Star St.
San Antonio, TX 78204

Texas Native Plants Nursery
Route 1, Box 161-K
Elgin, TX

Texas Pecan Nursery, Inc.
Box 306
Chandler, TX 75758

Texas-West Indies Company
P.O. Box 110
El Campo, TX 77437

Bob Turner Seed Company
Route 1, Box 98
Breckenridge, TX 76024

George Warner Seed Company
Box 1448
Hereford, TX 79045

Womack's Nursery
Route 1, Box 80
DeLeon, TX 76444

UTAH

Boyd E. Goble and Sons
Gunnison, UT 84634

C and S Intermountain Seed
Enterprises
Box 74
Ephraim, UT 84627

John C. Cook
387 North 800 East
American Fork, UT 87003

Kent Jorgensen
130 East Second North
Ephraim, UT 84627

Kyle Christensen
4485 Ebony Avenue
Salt Lake City, UT 84107

Mark Plummer
190 North Second West
Ephraim, UT 84627

Native Plants, Inc.
360 Wakara Way
Salt Lake City, UT 84108

Porter Walson Company
Box 1919
522 South Third West
Salt Lake City, UT 84110

Ron Stevenson
Ephraim, UT 84627

Roy Grosbeck
3522 West Cambridge
Granger, UT 84119

S. M. Clark
Box 606
Cedar City, UT 84720

Steve Regan Company
451 South 400 West
Salt Lake City, UT 84101

Stevens Brothers Wildlands Seed
and Nursery
Box 496
Ephraim, UT 84627

William Roger Steward and Sons
Box 124
Ephraim, UT 84627

WASHINGTON

Aldrich Berry Farm
190 Aldrich Road
Mossyrock, WA 98564

Briercrest Farms
Route 2, Box 70
Zillah, WA 98593

Brown Seed Company
Box 1792
12101 Northeast Twenty-eighth Street
Vancouver, WA 98663

Carl S. English
8546 Thirtieth Avenue
Seattle, WA 98122

Charles H. Lilly Company
West 228 Pacific Avenue
Spokane, WA 99204

Chenowith's Mount Vernon Nursery
South Second and Taylor
Mount Vernon, WA 98273

Clarke Nursery
Long Beach, WA 98631

Columbia Basin Nursery
Box 838
Quincy, WA 98848

Cy's Little Tree Nursery
817 Seventh Street, Southeast
Puyallup, WA 98371

Davenport Seed Company
Box 264
Davenport, WA 99122

Esses Tree Seed Company
401 South Seventh Street
Montesano, WA 98463

Forest Gardens Nursery
Route 1, Box 148B
Granite Falls, WA 98252

George Schenk
243 Northeast 119
Kirkland, WA 98033

Gosselt Gardens
4118 Main Street
Union Gap, WA 98907

Grays Native Garden
Route 4
Box 4385
Gig Harbor, WA 98335

Heather Acres
62 Elma Monte Road
Elma, WA 98541

Heather Acres
4730 132nd Place, Northeast
Marysville, WA 98270

Hillview Gardens
5405 West Mefaline Avenue
Kennewick, WA 99336

Jacklin Seed Company
East 8803 Sprague Ave.
Spokane, WA 99213

Jamieson Valley Gardens
Route 3, Box 648
Spokane, WA 99202

Manning Seed Company
Roy, WA 98580

May Nursery
Box 1312
Yakima, WA 98901

Moses Lake Conservation
District Nursery
Route 3, Box 415
Moses Lake WA 98837

Northrup-King and Company
East 5618 Sprague Ave.
Spokane, WA 99206

Northwest Ground Covers & Nursery
14461 N.E. 190
P.O. Box 248
Woodinville, WA 98072

Pacific Agronomy Company
Box 326
903 Houser Way North
Renton, WA 98055

Palouse Seed Company Nursery
P.O. Box 866
Tekoa, WA 99033

Pullman Plant Materials Center
Room 257, Johnson Hall
Washington State University
Pullman, WA 99163

Robert B. McNully
Route 1, Box 105
Pasco, WA 99301

Robert Dye
Pomeroy, WA 99347

Silvaseed Company
Box 118
Roy, WA 98580

W. M. Steward Nursery
Route 2, Box 225
Maple Valley, WA 98038

Viewcrest Nurseries, Inc.
12713 NE 184th Street
Battle Ground, WA 98604

Western Farms Association
201 Elliott Ave.
West Seattle, WA 98119

Western Tree Seed Company
Route 1, Box 99
Granite Falls, WA 98252

Weyerhaeuser Company
Tacoma, WA 98447

WYOMING

Carroll Riggs Seed Company
Shoshoni, WY 82649

Clouds Seed Company
P. O. Box 937
Sheridan, WY 82801

Mrs. Leone Byrne
Lyman, WY 82937

Paul Schiltz
Star Road
Box 223
Powell, WY 82435

V. H. Schiltz
Star Road
Box 282
Powell, WY 82435

Wayne Weber
Wheatland, WY 82201

Yoder Grain and Lumber Company
Torrington, WY 82240

GLOSSARY

abandoned farmland (gobacks): Lands that were used to produce crops in the past, but that are no longer used for production and lie fallow.

adapted species: Species that can complete their entire life cycle and replace themselves in succeeding generations. Both introduced and native species can be considered as adapted species.

alkaline soil: Any soil horizon that has a pH value greater than 7.0, but in practice, a soil that has a pH greater than 7.3.

annual species: A plant that completes its life cycle and dies in 1 year or less.

arid or semi-arid: Lands generally west of the 100th Meridian west longitude, where water used by native vegetation equals or exceeds precipitation. Annual rainfall is normally less than 25 cm (arid) or 40 cm (semiarid).

available nutrient: That portion of the plant nutrient supply in the soil that can be absorbed by plant roots and that aids in plant growth.

available water: That portion of water in the soil that can be absorbed by plant roots for growth.

banding: A fertilization technique used in agricultural systems in which the fertilizer is placed close to the seedling root system.

bareroot stock: A type of soil-free transplanting material made up of a portion of the root system with meristematic tissue that enables the root to sprout new above- and below-ground shoots.

biennial: A plant that completes its life cycle in 2 years, then dies.

broadcast seeding: Scattering seeds on the soil surface.

browse: Woody and herbaceous plant material that is eaten by livestock or wildlife.

bulldozer: See dozer.

bunchgrass: A grass growth form.

C-3; C-4: Two photosynthetic pathways.

cabling: A technique that removes dense, woody vegetation from large land areas using a cable attached to one or more bulldozers.

calcareous soil: Soil containing sufficient calcium carbonate to effervesce visibly when treated with cold 0.1 normal hydrochloric acid.

chaining: A technique that removes dense, woody vegetation from large land areas using a chain pulled by one or more bulldozers.

chiseling: The loosening of compacted soil by pulling a vertical blade through the soil. See ripping or sub-soiling.

clay soil: A mineral soil, made up primarily of hydrous aluminum silicates. Particles are less than 0.002 mm in diameter.

community: The fauna and flora that occupies a particular habitat.

compaction: The increase in density of a soil that results from reducing voids between soil particles by mechanical means.

containerized stock: Transplant material grown in containers with roots undisturbed in container soil.

contour: An imaginary line that connects points of equal height above sea level as they follow the relief of an area.

cool-season species: A species that makes its major growth early in the growing season and that generally has a C-3 photosynthetic pathway.

cover crop: A quick-maturing crop grown as a protective mat over the soil to reduce erosion and improve permanent vegetation establishment. See nurse crop.

crimping: A mechanical method used to hold mulches in place by pushing them into the soil; it is generally used for straw or hay mulches.

crust: A thin layer of hard soil or pebbles that forms on the soil's surface when it is dry.

cultivar (variety or strain): A group of cultivated plants that is clearly distinguished by characteristics from other groups of the same species. These characteristics are maintained in each generation.

deciduous: Refers to woody plants that shed their leaves every year at a certain season.

direct seeding: A method of establishing a vegetation stand by sowing seeds in the soil.

disking: A seedbed preparation that breaks the soil surface and that can incorporate soil amendments or remove herbaceous vegetation.

dozer basins: Depressions in the soil about 60 cm deep and 45 cm long made with a bulldozer blade to control erosion and modify the microclimate for improved seedling establishment.

dozer (bulldozer): Tractor with a steel blade mounted on the front end for moving soil.

drill seeding: A method of seeding that places seeds in the soil at a predetermined rate and depth.

drip irrigation: A watering system that delivers moisture to individual plants through a system of flexible perforated pipes.

ecoregions: Geographical divisions where climate, topography, and soil are uniform enough to produce a general characteristic fauna and flora.

effective precipitation: The portion of total precipitation that becomes available for plant growth.

electrical conductivity (EC): A laboratory method used to measure soluble salt content of a soil or water sample.

environment: The external conditions that act on an organism to influence its development or existence.

erosion: The wearing away of the land surface by water, wind, ice, or other geologic agents.

fertilizer: Any natural or manufactured material added to the soil to supply nutrients to plants.

fertilizer requirement: The quantity of a nutrient needed, in addition to the amount supplied by the soil, to provide the plants with a sufficient nutrient supply for growth.

fibrous roots: Any root system where most of the roots do not arise from the primary taproot or its branches.

forage: That portion of a plant that is palatable and that may be grazed or browsed by animals.

forb: Herbaceous plants without woody parts that are dicotyledons.

frost heaving: The lifting and moving of the soil surface and plants when the soil alternately freezes and thaws.

germination: The propagation and sprouting of seeds.

gouging: Manipulation of the soil surface to create shallow, long depressions to increase the establishment of seedlings.

grass and grasslike: Monocotyledons that generally have fibrous root systems.

grassland: A plant community dominated by herbaceous vegetation, primarily grass species.

growing season: A season that provides optimum growing conditions for the plant growth. The extreme limit of duration is the last killing frost to the first killing frost for warm-season plants.

grubbing: The operation of removing woody plants from an area, including the root systems.

habitat: The environment in which plants live.

harrowing: A seedbed preparation technique that breaks up large soil clumps and smooths the soil surface.

hay: The dried stems and leafy parts of plants used as a supplemental feed for animals or as mulch material.

herbaceous: Plant species that have no woody parts and that are dicots.

hydroseeding: Dissemination of seeds, mulches, lime, and fertilizers using a hydraulic system.

infiltration: The movement of water into a soil through pore spaces or cracks.

introduced species: A species not native to a given area but that may be adapted to the area.

legume: A member of the family Fabaceae, legumes are a widely distributed and economically important family that includes clovers, sweet clovers, alfalfa, vetches, and lespedezas. These plants fix nitrogen.

loam: A rich soil composed of a mixture of sand, clay, and silt.

map: Mean annual precipitation.

microclimate: A localized climate surrounding an organism that can result from variations in topography, vegetative cover, climatic conditions, land use, or any number of other factors.

mixed grass: A grassland type composed of short, medium, and tall forms and species of prairie grasses.

mulch: A natural or artificial layer of plant residue or other material placed on the soil surface to protect seeds, reduce erosion, and modify the microclimate.

native species: A species occurring in a given area as part of the original flora.

nitrogen fixation: The conversion of atmospheric (free) nitrogen to nitrogen compounds by soil organisms that may be associated with leguminous plants.

nurse crop: See cover crop.

nutrients: Substances taken into a plant to sustain its existence, promote growth, or provide energy, and allow reproduction and completion of the plant's life cycle.

palatability: A plant characteristic pertaining to the acceptability of a plant as a food source to an animal; it is a factor of taste, odor, and texture.

pasture land: Land used primarily for the production of domesticated forage plants, to be grazed by livestock or cut for hay.

perennial: A plant having a life span greater than 2 years.

pH: The symbol referring to a scale commonly used to express the degree of acidity or alkalinity: 1 to 6.9 = acidic, 7.0 = neutral, and 7.1 to 14.0 = alkaline.

pioneer species (volunteer): The first plant or animal species to invade and establish on a newly disturbed area.

pitting: A surface manipulation technique that forms small depressions in the soil surface to aid in water catchment and infiltration.

plugs: A small clump of plant material (one or more plants) that can be transplanted directly into the soil.

prechill: A germination technique that simulates natural winter freezing conditions. Prechilling is usually at 2°C for several days to several months.

precipitation: The deposition of moisture on the earth's surface from the atmosphere that includes dew, hail, rain, sleet, and snow.

PLS: Pure live seed.

reclamation: The process by which disturbed or depleted lands are returned to a productive state.

revegetation: The establishment of vegetation following disturbance.

rhizomatous: A plant having rhizomes as a method of reproduction.

rhizomes: Underground stems that usually have fibrous roots and that can develop aboveground shoots.

riparian: Vegetation community usually associated with stream and river banks and lakesides.

ripping: A very deep seedbed preparation method that breaks up deeply compacted soils. See subsoiling.

roller chopping: A site preparation method that cuts woody species into small pieces to act as surface mulch and to speed up the decomposition process.

root plowing: A site preparation method that removes vegetation by cutting the roots off just below the soil surface.

rotobeating: A site preparation method that removes brush by flailing and chopping.

runoff: That portion of precipitation on a given area that is discharged from the area by channels, overland flow, or through belowground movement (seepage).

saline soil: A soil with an electrical conductivity greater than 4 mmho/cm.

sand: A mineral soil with particles between 0.05 and 2 mm in size.

savannah: A plant community where woody species are scattered throughout dense herbaceous stands.

short grass: A plant community dominated by short grass species.

shredding: A site preparation method that chops up woody vegetation.

shrub: A woody, perennial dicot that may have one or more stems.

shrubland: A plant community dominated by shrubs.

silt: Small mineral soil grains with particles ranging from 0.05 to 0.002 mm in size.

sod former: Any plant species whose growth form produces a relatively continuous mat of vegetation. Generally, it is used to describe rhizomatous and stoloniferous grasses.

sodium absorption ratio (SAR): A laboratory measurement of the ratio of soluble sodium to soluble calcium plus magnesium in soil and water.

soil amendment: Any material added to the soil that increases the productivity of a soil.

soil association: A technical unit used to classify soils for management planning and action.

soil horizon: Contrasting layers of soil parallel to the land surface. The A horizon is the uppermost layer (topsoil); the B horizon is the layer immediately below the A horizon and has less organic matter, biological activity, and root biomass (subsoil). The C horizon is less structured material and has the least biological activity.

soil texture: The relative portions of sand, silt, and clay in a soil.

sprinkler irrigation: A method of mechanically applying water for plant growth that simulates precipitation.

stabilize: To establish a stable condition by planting vegetation or by mechanical or engineering means on a given land area.

stolon: A modified, horizontal, aboveground stem that has roots and aboveground shoots at the nodes.

stoloniferous: A plant having stolons.

subsoil: The B and C horizons of the soil.

subsoiling: See ripping.

succession: The process whereby one plant community is replaced by another through a natural growth and maturation process.

survival rate: The percentage of plants surviving over a given time period.

tackifier: A chemical substance applied over mulch to temporarily stabilize the mulch on a site.

tacking: The process of binding the mulch to the soil surface by mechanical or chemical means.

tall grass: A plant community that is dominated by tall grass species.

taproot system: A root system that has a large central primary root with secondary roots attached.

terrace: Sloping groundcuts into a succession of level benches and steep inclines to control erosion and runoff.

topsoil: The upper soil horizon where most of the biological activity occurs.

transplanting: A method of revegetating disturbed areas using containerized, bareroot, ball and burlap, or other vegetative propagules of plants.

tubelings: Seedlings grown in small, flexible individual cartons under controlled growing conditions.

warm-season species: A species that makes its major growth in the warm portion of the year, primarily in the summer. These species generally have C-4 photosynthetic pathways.

water harvesting: The practice of manipulating topography to collect runoff water and concentrate that water to an area for plant growth, usually by construction of catchments, dams, terraces, or other water retention structures.

water quality: A term used to describe the chemical, physical, and biological properties of water in relation to its suitability for a specific purpose.

wildlife: Undomesticated vertebrate animals, excluding fishes, considered collectively.

woodlands: A plant community that is dominated by trees.

xeric: An arid or extremely dry environment.

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